WORKSHOP PRACTICE SERIES FROM SPECIAL INTEREST MODEL BOOKS

[illegible]

36. Photo Etching

Photo etching in the form of electronic equipment printed circuit boards [illegible] familiar to all modellers [illegible] the application of [illegible] techniques to [illegible] production of [illegible] parts for all aspects of [illegible] making ranging from finely detailed [illegible] and traction engine emblems and nameplates.

Authors Brian King and Azien Watkin have developed photo etching techniques to a high degree of sophistication to enable Brian to [illegible] winning marine models. The design of [illegible] and the production of the high quality graphics necessary are fully covered [illegible] outer to producing the finished [illegible] a variety of [illegible]

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PHOTO ETCHING

Brian King and Azien Watkin

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Brian King and Azien Watkin May 2004

"The hand is the cutting edge of the mind" *Jacob Bronowski*

PREFACE

Photo etching, otherwise known as chemical milling, has been used in industry and to a lesser extent by enthusiasts at home for many years and readers of this book are likely to have peered into a transistor radio or a television set or perhaps a computer and seen electronic components soldered into printed circuit boards made by this process. Only those, however, who have experience of electronics before the printed circuit board and miniaturisation, using hard wiring and a chassis, will appreciate fully the advantages brought by this new technology.

Before such technology was available to modellers the production of highly detailed, high precision model parts was achieved often by repeatedly discarding unsatisfactory efforts until a single acceptable example could be proudly displayed. Making the same item in multiple quantities or in a mirror image was often within the capabilities only of a skilled hand-worker with specialised tools and equipment.

A select few modellers realised however, that photo-etching offered almost limitless opportunities because almost anything which could be set out on the drawing-board could be produced in metal by a stress-free chemical process, a leap into the future of similar proportions to that experienced in the electronics industry. Others, however, often in ignorance, viewed photo-etchers with the suspicion and awe accorded to alchemists of old.

Now the time has arrived to cast aside the veil of mystery and to reveal to all the secrets of the trade. The authors have set out in this book to document their considerable experience in manual drafting, computer aided design, commercial etching and home brewing at the kitchen sink. All the techniques have been fully proven and anyone who has seen the models containing the fruits of the authors' work would be hard-pressed to challenge their capabilities.

Once you have realised what marvels you can produce yourself with a very small capital outlay and a modest talent for drawing there will be no turning back!

David Watkin 2004

Fig.1.1 Most of the detail work on this model of the aircraft carrier HMS "Glorious" is a result of photo etching. The girder work under the round-down, the catwalks, cranes and guardrails are all brass etchings. Scale 1:192.

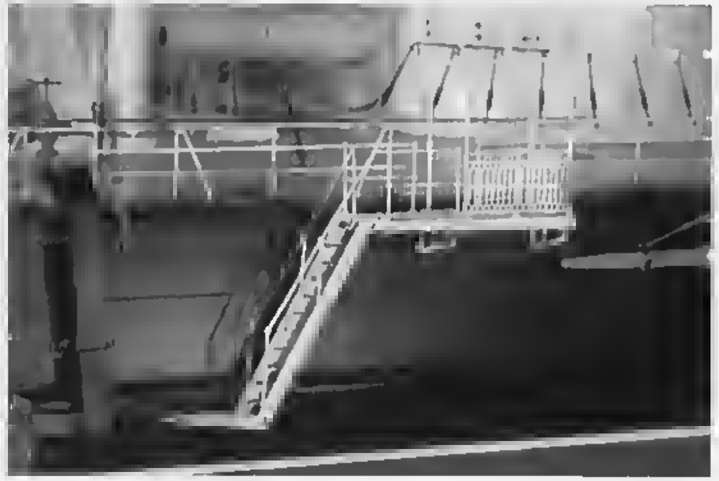


Fig.1.2 This complicated accommodation ladder was built up from several etchings and soldered together. The ship is the Italian battleship RN "Duilio" (1876) at a scale of 1:100.

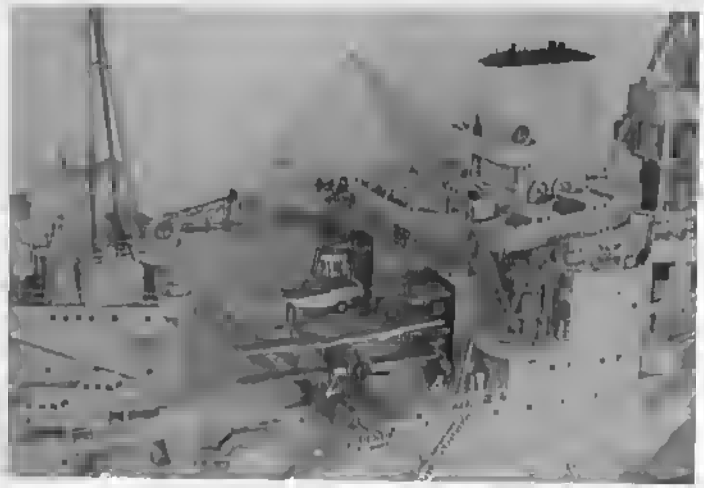
CHAPTER 1

INTRODUCTION

Photo etching puts an extremely useful tool into the hands of all model makers both amateur and professional. This is a book about photo etching, how it is done and more to the point, how to produce the all-important preliminary stages: the design of components and the artwork. After our first book on the subject one reviewer took us to task in that we had not devoted enough space to home etching. Whilst we hope we have covered the subject more fully this time we remain convinced that large sheets of etchings are best left to the professionals. However, we ourselves have often found that you need relatively small components quickly to avoid hold-ups in the building process and therefore knowledge of home etching is almost a must.

Before computers the drawing board held sway. My generation grew up with them and they have followed me all my life. My first attempts at artwork were done on

Fig.1.3 My model of the battleship HMS "Queen Elizabeth" modelled before her aircraft were removed. Etching has been used extensively for cranes, ladders, guardrails and even the aircraft have many etched parts: wings, tails, struts, propellers, etc. Scale 1:150.



the drawing board and only recently have computers ousted my manual efforts. Some of our readers will still want to draw their artwork whilst the computer-wise will exploit the accuracy and speed of their computers.

We deal with both methods, remembering that the final etching can never be better than the artwork.

The examples used to illustrate the process are largely biased toward model ship work as that is our main interest. However, it must be emphasised that the process is completely universal and can be applied to any kind of work that requires very fine detailed parts.

Photo etching basics

At its very simplest – a sheet of metal is coated with a light sensitive emulsion, which is exposed to UV (ultra violet) light through a transparent acetate sheet that has a design imprinted on it. The areas unprotected from the UV light (i.e. the transparent areas) will be washed off in the developer, leaving the component (black areas) protected from the etchant. The exposed metal areas can then be attacked by the etchant (usually ferric chloride) and dissolved away. The all-important artwork is necessary to provide the design(s) on the acetate. As we shall see the process can be elaborated. The whole process is akin to the production of printed circuit boards (PCB's) although these have a backing of fibreglass or sheet resin bonded paper (such as Paxolin), which we do not need.

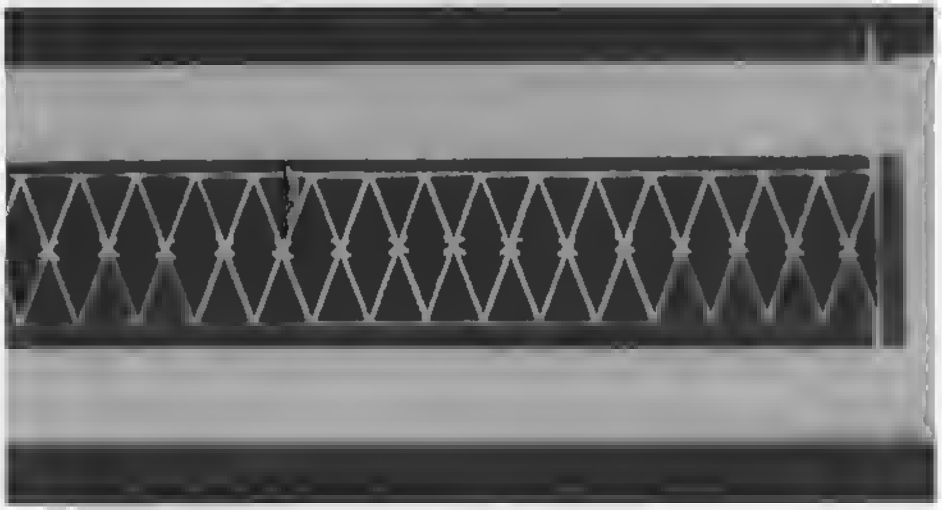
The photos show some examples of the application of photo etching to some complicated model boat and aircraft parts. The fine detail obtained with etching is very difficult to achieve any other way. **Figs.1.1-1.6.**

Fig.1.4 *An Hawker Osprey with folded wings. Virtually all the parts are etchings except the fuselage and wheels. The overall length of this model is 46mm (1:192 scale).*

Fig.1.5 *We come back to square one, as it was the railings for an Admiral's walk that started it off. Here is the Admiral's walk on the Victorian battleship HMS "Magnificent" (1894). Scale 1:110.*

Fig.1.6 *HMS "Camperdown" showing the flexibility of the technique with the guardrails round the bridge binnacle. Scale 1:110.*

Fig.2.1 Another example of the guardrails, this time on the Victorian battleship HMS "Empress of India". ***Below:*** ***Fig.2.2*** *Shows the photo negative of my original drawing which was produced 4 times full size.*



CHAPTER 2

USES, ADVANTAGES AND LIMITATIONS OF PHOTO ETCHING

The basic advantages of photo etching to the model maker are really two-fold. Primarily it's great advantage is that parts of really intricate shape can be easily made; parts which cannot be produced any other way.

Secondly, any number of the same part can be easily replicated by the etcher using a stepping camera to produce as many images as required or, if a computer is used, the same effect can be achieved by "rubber stamping".

The first time I used photo etching to overcome a problem was on a Victorian battleship, HMS "Empress of India". This ship, as well as any other battleship of the era that was ever likely to carry an Admiral, carried an Admiral's walk. For the uninitiated this comprised a V-shaped platform surrounding the stern of the hull. This gave the Admiral privacy as his quarters were adjacent and he could stroll around out of sight of the ship's company. **Fig.2.1.**

The problem involved the guard-rails. They always consisted of a diamond shaped interlocking pattern probably made up of cast iron sections. This intricate pattern defied any orthodox methods of production. My neighbour, who was a professional model maker, suggested photo etching as a solution.

A drawing four times full-size was prepared and the resultant model size transparency is shown in **Fig.2.2. (Fig.2.2A** shows the brass etching produced from using this). The only problem was getting the length absolutely correct to fit around the base. With its complexity it obviously could not be cut or extended. The result

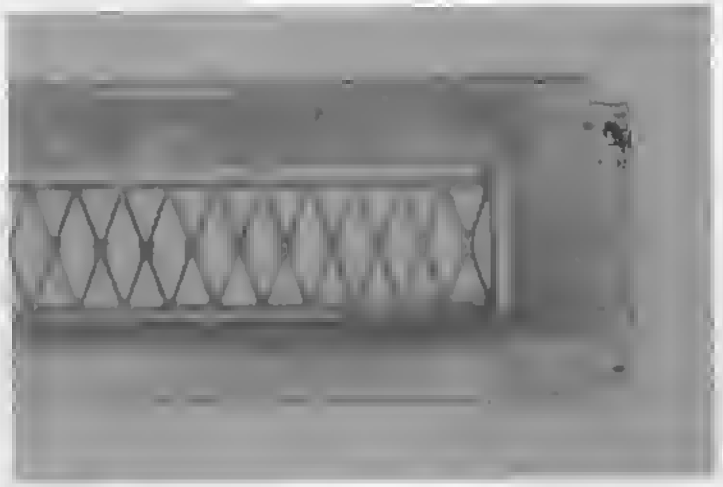


***Fig.2.2A** Brass etched rail produced from the photo negative shown on the previous page.*

was magic. It was clear that a marvellous new weapon was added to the armoury and could be used extensively on any further models, which it has been. Each succeeding model has carried more etched parts than the last. Once adopted more and more ways of using the process present themselves. Below are some examples of the use of etching where the components cannot be easily made any other way. These are of model ship components because that is our field but any branch of model making can usefully adopt the process. The model railway people have really embraced this technique whereas the marine people have not shown a great deal of interest up to now.

The process of photo etching produces no physical stress on the component unlike cutting and filing, both of which will cause distortion and burrs. This distortion largely limits very fine work being done using physical methods. As no stress, except at molecular level, is applied, very intricate parts can be produced without any burrs or distortion. These may cause you handling problems but that is another matter entirely. Etching does not only produce the outside shape of the parts but, as we shall see, can provide surface detail, rivet heads, strengthening ribs, etc. You may say, but fine, delicate work is done without using etching: clock and watch hands for example. This is so, but very complicated and very expensive press tooling in all probability, produces them. This can only be done if the number of components required is very large so as the cost of the tooling can be amortised. Etching can be just a "one off" process.

Surface detail

Surface detail can include panelling, planking, folding lines, etc. If a sharp fold is required the material can be half-etched with a fold line on the back so that at the point of the fold the material is only half thickness. This results in a sharper fold than if the full thickness of the material is involved. It makes folding easier and also locates its exact position. **Fig.2.3.**

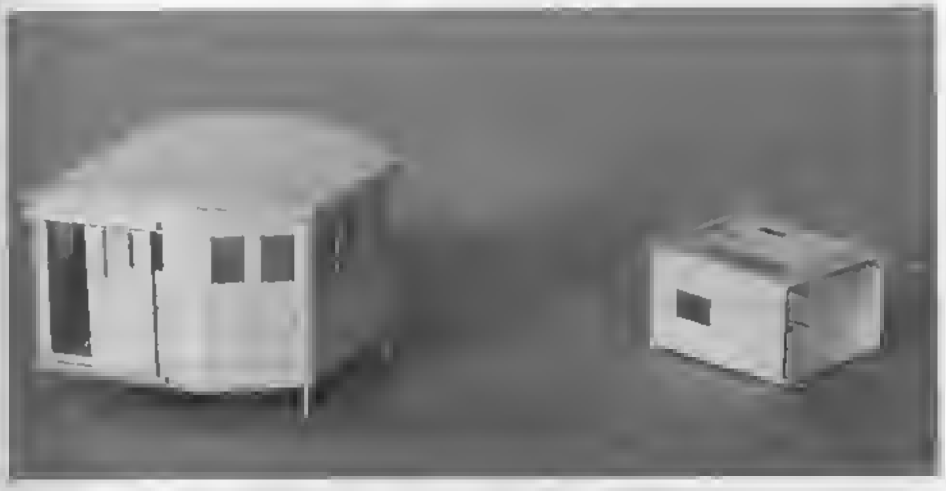


***Fig.2.3** The left hand component is the enclosed bridge structure and the right hand the aft bridgehouse. They have been folded using half etched (from the back) fold lines and the panels were also half etched (from the front).*

Positional accuracy

Another advantage is that the position of holes, folds and other details can be determined extremely accurately when a computer is used at the design stage. Even using a drawing board it is easier to mark these positions in the flat, as it were, rather than trying to manipulate a tiny etching at a later stage.

This accuracy feature can be used in other ways. Ships often have built-in ladders on their hull sides, masts, etc. Making these requires two parallel sets of holes into which the rungs can be fitted. Now if you are skilled and have the equipment these can be put in using the indexing dials of your milling machine. I have done this and a tricky job it turns out to be. You can, however, etch a drill template, possibly even with built-in locations very easily and very accurately. You can also etch the U-shaped rungs; check the centre distance between the legs and that of the hole centres. If you are still with me they should

***Fig.2.4** An etched drilling template together with two etched rungs.*

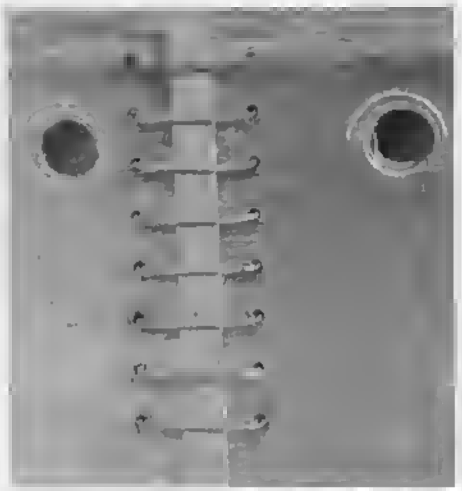


Fig.2.5 The resultant hull ladder. The strip of wood is primarily for spacing out the rungs but is left in position for protection against accidental knocks. Note the "etched in" rigols.

be the same. This makes fitting this type of ladder a piece of cake. **Fig.2.4** and **Fig.2.5.**

Hole drilling

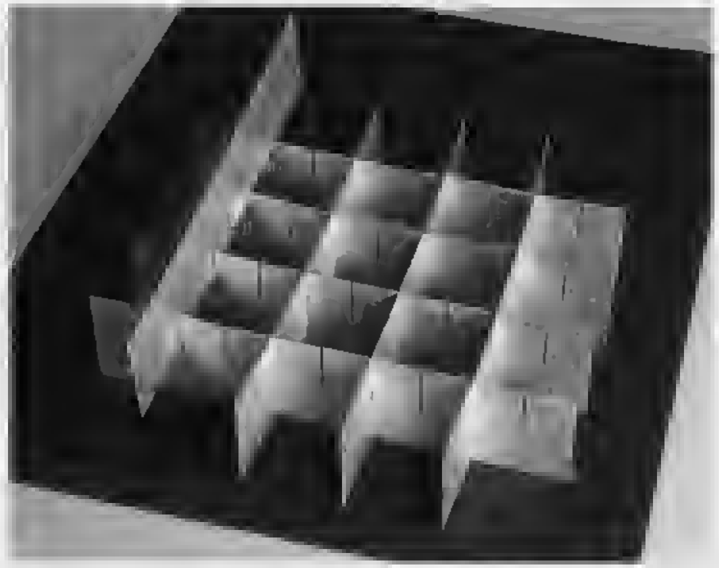
Talking about drilling holes brings up the subject of portholes. Drilling a clean hole in a wood hull is difficult. On my last model, HMS "Camperdown", which was only a waterline model, the hull sides were faced with etchings. This disposed of the problem completely. The rigols, or eyebrows, above the ports were etched **IN** and did not stand proud as they should. **Fig.2.5.** At that scale (1/110) this completely deceives the eye. A soft pencil was rubbed into the groove, which glints in the light and helps the deception. **Fig.2.6.**

Building stacks for thickness

The accuracy and repeatability can also be exploited particularly if a computer is used to "rubber stamp" components. For instance you may be only using 0.008in sheet but components may be built up using a number of layers. An example is the problem of making warships' flag

Fig.2.6 The etched rigols after painting and pencilling in, as described in the text. Note the etched cage around the lifebuoy.

Fig.2.7 Showing "egg box" technology.



lockers. These are cabinets about 6ft square, divided up into many small compartments which house signalling flags. One way of making these divisions is to use the "egg box" principle using vertical and horizontal partitions with half joining slots. **Fig.2.7.** These can be etched but are the very devil to assemble. Another way to build

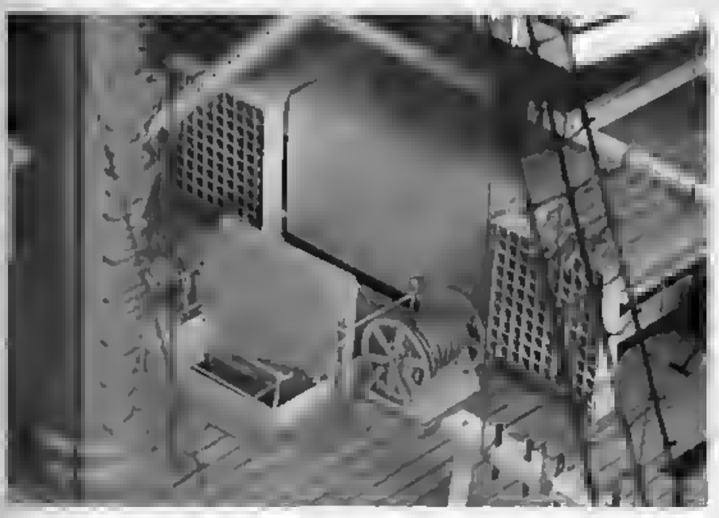


Fig.2.8 The flag lockers on HMS "Camperdown" (scale 1: 110). These were made by the second method described in the text.

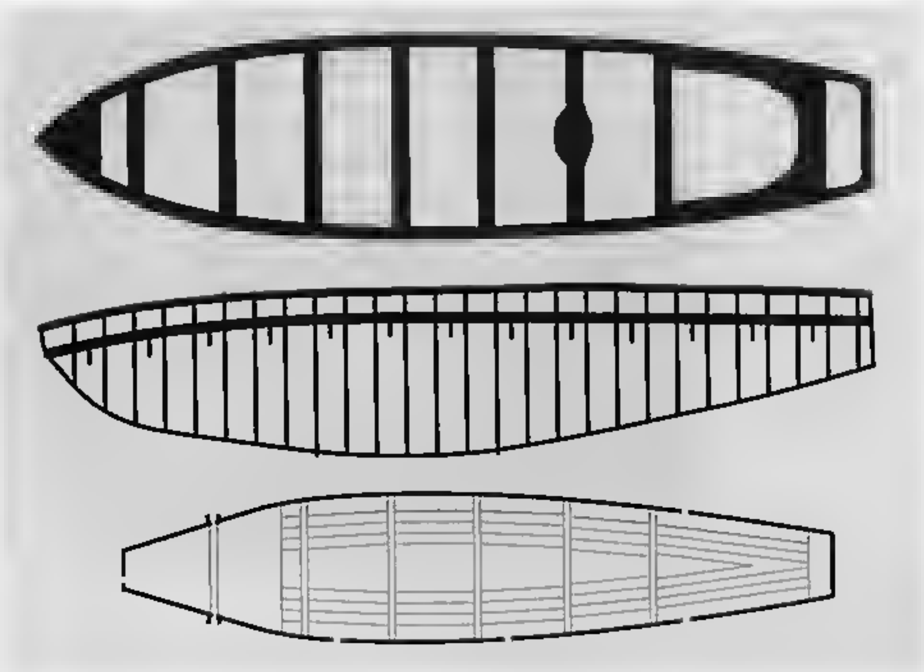


Fig.2.9 Etched parts for a ship's boat. Two sets of ribs would be required. The bottom boards have been half-etched to simulate the separate planks.

the same is to etch a grid showing all the partitions and just use as many layers to fill the outside case (which is the cabinet) as necessary. **Fig.2.8.** The cabinet itself can be folded from a developed flat shape. A-frames for winches, etc. can be made the same way, soldering or gluing up a number of identical etchings into a stack.

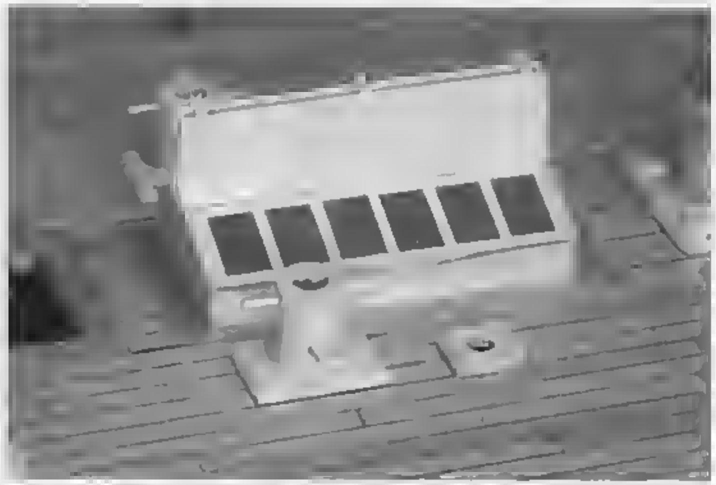
Pierced parts

The production of pierced parts i.e. with holes of various shapes can be a very tedious job if orthodox methods are used. With the etching process all you have to do is to draw them and the etchant does the rest.

Etchings for ship's boats

Fig.2.9 shows three etchings for a typical ship's boat. The top one combines the thwarts, shelf and stern sheets in one piece. This is a bit naughty as, in real life they are not combined, but on the very small scale required it works well. The middle etching is a combined inner wale (at the top), shelf and timbers (ribs). Two of these are required, of course – port and starboard. The little tabs below the shelf are bent out at right angles to support the first etching. Before fitting these ribs they need to be annealed otherwise they will not dress into the shell of the boat. Discrete snipping of

Fig.2.10 Perspex skylight with etched appliquéd windows and cover plates.

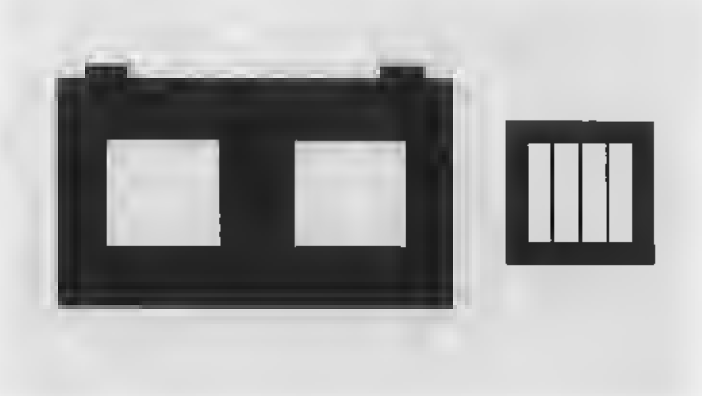


the lower edge will be required to remove excess material. This will not show as the footboards (the lower etching on the figure) will sit on top. It is essential when designing these etchings that the boat shell is made first and the components made to fit. If they are copied from the drawings they will invariably turn out too large.

Applique

Fig.2.10 shows a skylight assembled, painted and fitted to HMS "Camperdown". **Fig.2.11** shows the part to be fitted to the top of the Perspex body of the skylight (left) and, on the right, the frame with protecting bars, which is appliquéd on top of that.

Fig.2.11 Skylight parts. The right hand part with its protective bars fits over the basic left hand part.



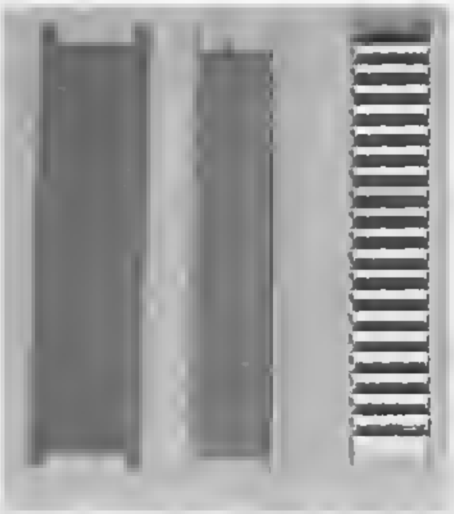


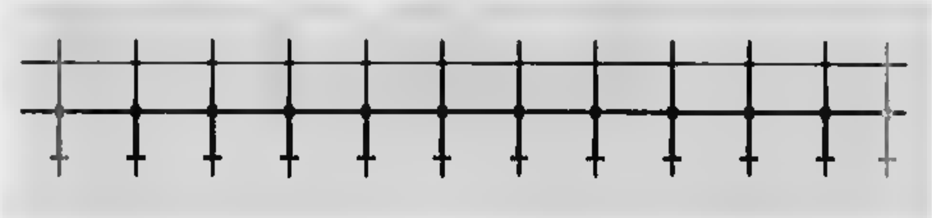
Fig.2.12 A brass etched ladder. The left hand part is the etched blank. The centre view is with the stiles bent up and the completed right hand view has the steps folded up. As explained at some length in the text the ladder operation depends on the "neck" of brass at each end of the step which, in turn relies on a proper understanding of etching drawing design. The design of such ladders on a drawing board can be a bit hit and miss. ***Below:*** ***Fig.2.13*** *This is a length of etched guardrail of the wood-capped type. The top line is really redundant but is there for stability and on assembly can be removed.*

Freestanding ladders

Fig.2.12. The process also lends itself to reducing the number of components that have to be made and assembled. Take ladders tor instance where, with a bit ot care, not only the stiles and steps can be etched as one piece but also the handrails. This results in a folding job rather than an assembly where you solder three steps into position only to find that two ot the previous ones have tallen off. It the scale is small enough long lengths ot guard-rail can be etched as one piece. These can be designed with all their fittings to actually fit the job in hand. It these are bought ready-made inevitably they will not fit the existing structure correctly. It the scale is not too large etching can save a great deal ot turning work.

Guardrails

Fig.2.13 shows a set ot guardrails of the type having a wood cap rail. Each stanchion has a lower pin tor securing to the deck and a top pin tor holding the wood-capping rail. The top horizontal line is only there to steady the etching and to maintain some semblance ot stability when fixing down and will be removed on fitting the cap rail. The extreme left-hand stanchion will be halt etched trom the back and the extreme right hand stanchion half etched from the front. This is to allow lengths of guardrail to be fitted together.



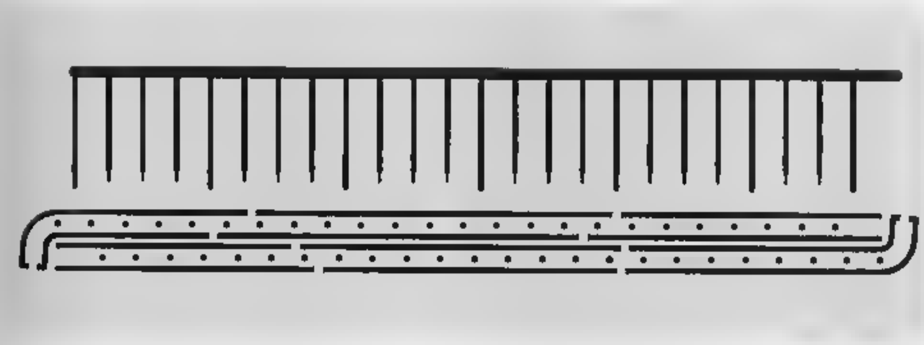


Fig.2.14 A rung-type ladder with a "ladder comb" for easy assembly.

Jigs and fixtures

Another example of the use ot accuracy is the ability to design your own jigs and tixtures. **Fig.2.14** shows two ladder stiles and what we call a "ladder comb". This type ot ladder with round rungs is normally fitted to vertical sides, funnels, masts, etc.

They differ trom the sloping ladder that has steps rather than rungs. The ladder comb is designed to make assembly easier, as the two side members are simply threaded onto the comb that holds all the rungs in the correct position tor soldering or gluing. It is then trimmed off. Yes, I know the rungs will not be round but this is for SMALL ladders!

Rope ladder

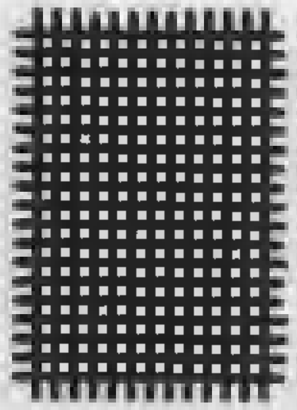
Etching can be used tor objects not made ot rigid materials. **Fig.2.15** shows a rope ladder of the type found hanging from ship's mooring booms.

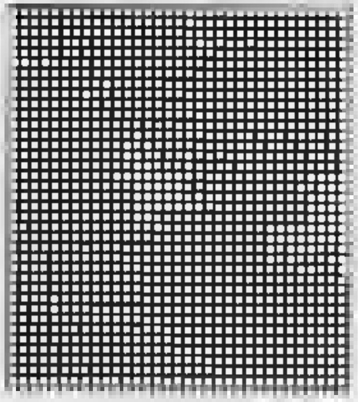
Perhaps there is one turther point to stress. When you receive your etchings back an enormous amount ot work will have been done. If you have designed and drawn the parts correctly allowing for assembly and fixing (i.e. extra holes, tabs, etc) the rest of the work should be relatively straightforward although, as we shall discuss later, pitfalls will still exist.

It all looks very easy and simple and, to the uninitiated, it may look like cheating. The tact is that nearly all the work has already been done in preparing the artwork that takes a great deal of skill, time and effort.

The parts finally obtained are of metal with all that implies. They can be surface etched with extra detail, they can be bent or folded, and they can be soldered or glued. You also get a superb surface on which to paint – no grain tilling, etc. Unlike plastic, which has limitations in mould design and injection problems they can be made to scale. For example, ship's railings on small plastic models have to be made over scale and always look wrong.

The great Austrian ship modeller Friedrich Prasky uses etching to a very great degree, making complete turrets, etc. trom etched parts. We understand he does the complete process from drawing to etching.





Above Left:* Fig.2.15** *An etched rope ladder. Above Centre:* ***Fig.2.16 *A ship's grating likely to be found on the deck around the steering position. No problem in etching this relatively coarse grating should be encountered. Above Right:* ***Fig.2.17*** *An example of a fine grid likely to be wanted for ventilator covers and the like.*

Limitations of photo etching

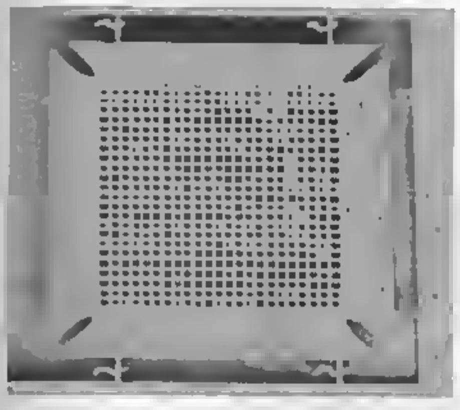
Having discussed the advantages what, if any, are the disadvantages? As has been described the method uses a "resist" to control the action of the etchant. This is a surface coating only and therefore if the etching process is continued for any length of time the etchant can start to eat its way under the resist. One advantage of using a professional etcher, as opposed to using a dish of etchant, is that the machine used sprays the etchant onto both sides of the work thus speeding up the process, as the surfaces are in continuous contact with fresh liquid.

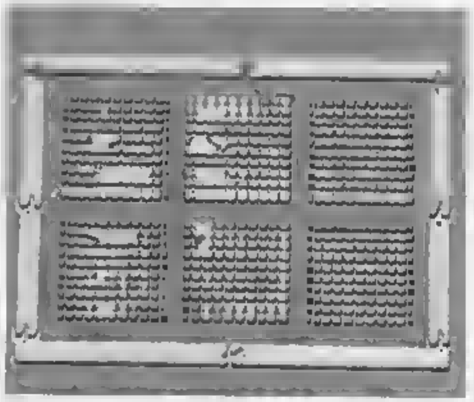
As a general rule therefore the thinner the work the better the result as the etching time is reduced to a minimum. With the thin sheet mainly used this undercutting effect can be ignored but, for the difficult-to-please, even on thin sheet, things like guardrails will end up slightly thinner than drawn. Increasing the width of the lines may compensate for this.

Gratings and grids

One point to remember when designing etching work is that of the total resolution of the system. The easiest way to show this is probably by example. One type of component often required, in model boat work at least, is a grid. These may be to simulate relatively heavy wood gratings, often found on the deck around ship's wheels, for the helmsman to stand on or for much lighter wire meshes guarding vents, meat safes, etc.

All these grids will consist of crossed lines leaving square spaces. According to the ratio between line thickness and space areas you can end up with either the lines etched out so no grid exists, only a hole, or if the ratio is reversed no holes show and you get only a blank square. Both are





***Above Left:* Fig.2.18** *A brass etching showing a grid with some of the holes obscured.*
***Above Right:* Fig.2.19** *A grid with the bars burnt out.*

equally useless. What has happened is that the whole system has been pushed too far. It may be camera resolution or it may be etching problems. **Fig.2.16** shows a simulated wood grid that will give no trouble, as it is relatively coarse.

Fig.2.17 shows a finer grid than **Fig.2.16**, to simulate a wire mesh. We experimented with various line widths and spacings. It was found that, at x2, a line width of 0.4mm and a spacing, line centre to line centre, of 1.2mm gave the most satisfactory result. Of course, if you are using Computer Aided Design (CAD) to produce electronically transferred data the grid can be drawn to size i.e. line width 0.2mm/space 0.6mm. Any other line/space ratio may result in etching errors. See **Fig.2.18**, which shows a grid blocked in and **Fig.2.19**, which shows a grid burnt out.

Unfortunately the etching process is really only two dimensional. For some models some 3D components can be made by developing the part into a 2D shape. For large models this may not be feasible. An example would be round runged ladders. Above a certain size the rungs MUST be round and not flat as you inevitably get if you etch!

Weight

The weight of etchings may be a disadvantage e.g. for flying models and possibly working boats.

Toxic chemicals

Home etching does involve toxic chemicals that attack metal so care should be taken using protective gloves and goggles when handling the chemicals and using the etching baths.

Costs

Lastly the cost of commercial etching work may seem expensive but, if amortised over the length of building a model, it is not very great. The main cost component is the photography. The actual cost of a sheet of etchings is relatively small but it pays to get as much work as possible onto a sheet. As we shall see later with electronic transfer, cutting out the photography reduces the cost.

CHAPTER 3

PREPARATION OF ARTWORK USING THE DRAWING BOARD

When I first started to use the photo etching process the artwork was produced on a drawing board as, at that time we had no computer. This didn't pose a problem to me as I had been a full-time draughtsman for a considerable number of years and seemingly a part-time one ever since!

The task is to generate a drawing that will enable your etcher to produce two acetates (photo tools) one for each side of the metal sheet. These acetates will have the etching design printed on them. This design will be transferred, using ultra violet (UV) light to the light-sensitive emulsion coating on the brass sheet. When the coating is developed some areas of the emulsion will wash off and some will remain as the "resist".

The first thing you need to know is how large a drawing your etcher can handle. It is very galling, and it has happened to me, to prepare a large drawing only to find the camera your etcher has cannot take it. You really need to know this and other parameters, such as maximum size of etched sheet. So choose your etcher and find out his requirements first before launching into anything. Our normal etching sheet size is 18x12in. which makes the drawing sheet size, at x2, 36x24in.

Normally with orthodox drawing methods you expect to draw artwork larger than the finished part. This is for three reasons: it reduces drawing error, it's easier to draw at a larger scale, and it cleans up the image. The maximum size of drawing and the maximum size of finished etching may be the deciding factor but I have found x2 satisfactory. This will halve the scale of any drawing errors and makes drawing very small parts easier. Your etcher will need to know this, of course, so put the scale of the drawing on the drawing.

Before any work can be done you must decide on whether you need a positive or negative drawing or both.

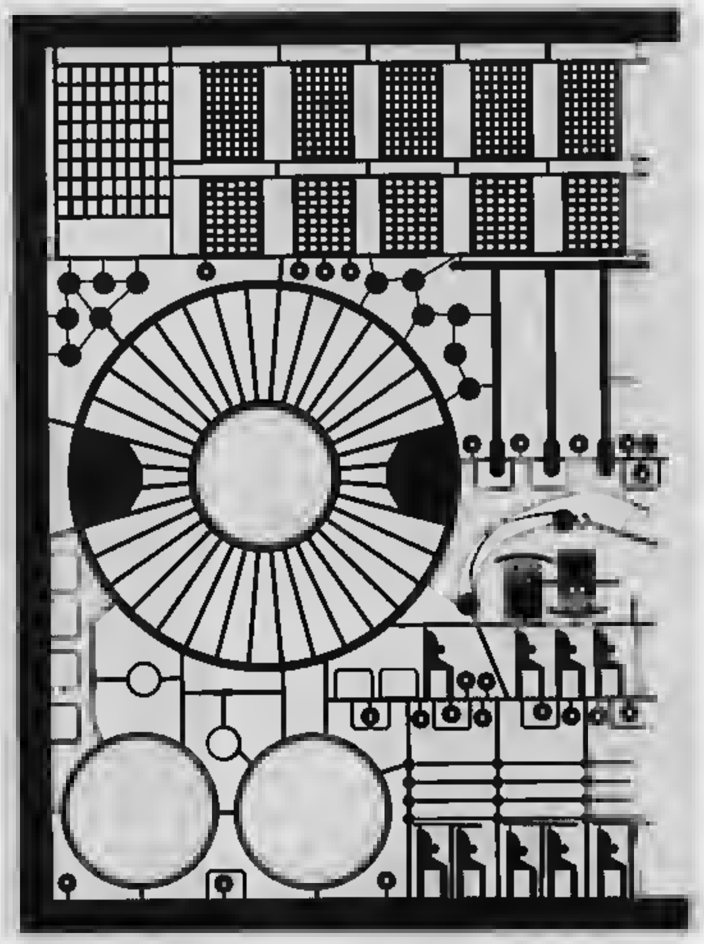


Fig.3.1 Part of a negative etching drawing. The grey areas are half-etched from the front.

Positive and negative drawings

Fig.3.1 shows part of a typical negative drawing and **Fig.3.2** part of a positive drawing.

Artwork can be presented in one of two modes. Possibly both modes will be required on any one model.

Positive drawings

Any "area" type shapes are usually drawn as positives. That is, the shape is surrounded by a cutting line which simply cuts out the shape required. The drawn line must lie outside the shape wanted otherwise the component will be smaller

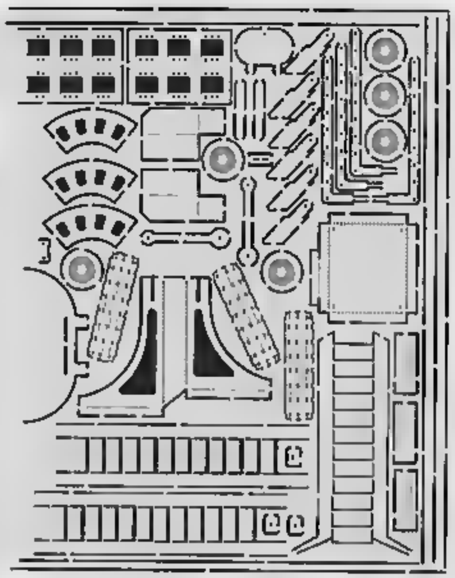


Fig.3.2 *Part of a positive etching drawing, again note the half-etched detail shown in grey.*

Fig.3.3 *Ship's guardrail etchings attached to the frame of the sheet and to an inner supporting frame.*

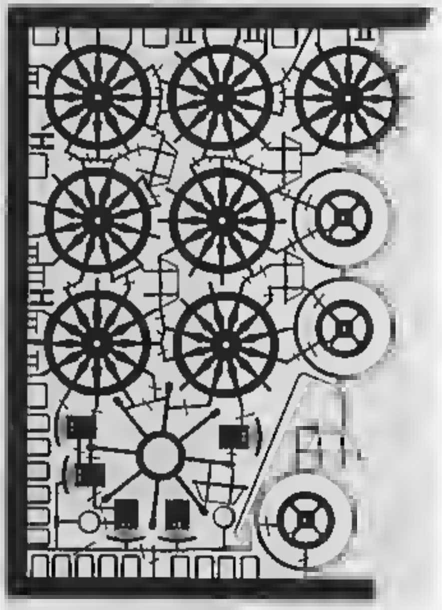


Fig.3.4 *Freehand linking of components. This saves etching area but can be more difficult to lay out and to cut out. The "crossed" lines are connectors and not part of the component.*

than designed. Likewise any holes will require the cutting line to be inside the shape for the same reason. Holes should be blacked out to avoid them dropping out into the machine. They will then simply etch away. Larger holes or areas can be retained by nicking (as described later) and the material re-used.

A moments thought will make it obvious that if the cutting line completely surrounds the part, it will drop out of the matrix as the etchant cuts through the sheet. This will annoy your etcher, as it will foul up his machine, and annoy you even more when you get your sheet back with holes where the parts should be! Nicking the lines at intervals solves this problem – about a 0.5mm nick is usually sufficient. If the drawing is on film a scalpel can be used to scrape off the ink. This is usually easier than trying to draw an interrupted line.

Negative drawings

Components which largely consist of lines such as ship's guard-rails do not really suit the above technique, as they require two closely drawn parallel cutting lines to produce thin strips. It is obvious that such strips are best produced in black by a pen of the Rotring type rather than by two parallel cutting lines. So negative drawings show the parts as black images rather than as areas surrounded by black lines. With this type of drawing the black components must be held into the matrix by black connecting lines to prevent them falling out. Unlike positive drawings the black elements are **not** the areas etched away. **Fig.3.3** shows guard-rails connected into a grid pattern for support and **Fig.3.4** shows components linked together with a more freehand technique.

The technique I have found satisfactory is to draw the components on tracing paper in pencil first and then trace them on to drawing film using tubular ink pens e.g. Rotring. These, unlike old draughtsman's pens, give you a constant line width. Firstly draw the borders to avoid exceeding your maximum size. At the tracing stage you can rearrange parts if necessary. If the drawing is in negative mode you will have to decide whether you will encompass each part with a grid, or join parts "freehand". If the drawing is in positive mode it will need to be "nicked", that is if you ever want to see your components again!

Try to get as dense and as accurate a line as possible to produce a first class image. The etcher would like black lines on white card to get as much contrast as possible but that has disadvantages. It is difficult to send large cards through the post and the use of transparent drawing film is so convenient when tracing. When photographing your master on film it can always be backed with white paper. The use of film produces a much more stable image than tracing paper and it is also more durable.

The use of tracing paper as the first stage allows for tracing of parts from your working drawings. If you are working x2, for instance, you cannot do this directly but need to photocopy your originals up to x2 and trace these to get the scale correct. Using a photocopying machine is most useful but it must be of the variable scale type. Drawings in books of the "Anatomy" kind contain the drawings of armament, ship's boats, etc. that you may require, usually drawn to a known scale. The scale will never be the one you are working to but that's life! From these you can calculate

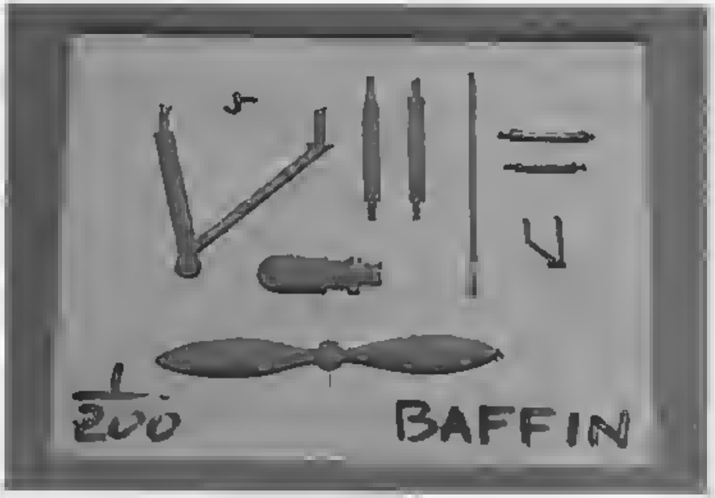


Fig.3.5 The top face of a polycard template (stencil) for making aircraft parts.

the conversion factor expressed as a percentage to produce a photocopy, model size and a further copy x2 for etching purposes. Although your etching drawing needs the x2 copy it is an excellent idea to have a drawing of the correctly sized component as well, just to keep things in proportion.

Scaling drawings

An example: say the drawing of a boat is 4in long at 1/150 scale and you want its length at 1/100 scale. The ratio will be 150/100 = 1.5 or 150%. The boat will then measure 4x1.5in = 6in (100x1.5 = 150mm).

So to change the scale the conversion factor to punch into the photocopying machine will be, in this case, 150%. Always check that you get the ratio the correct way round by asking yourself – will it be larger or smaller than the original? With some machines and some drawings the correct size must be achieved in two or more stages because the machine has too small a range.

Use of stencils

Parts with irregular outlines which cannot be easily constructed from straight lines and regular curves are very difficult to repeat on the drawing board. In these cases stencils provide a solution. They can be drawn as female or male shapes. It is usually easier, in practice, to run your pen around a hole shape rather than try and keep it "glued" to the edge of a male shape. **Fig.3.5** shows samples of female templates made for aircraft parts. They are made from 0.010in thick polycard that is usually stout enough; thicker material is stronger but more difficult to cut. The profile needs to compensate for the diameter of the pen tube, that means the hole has to be larger than the shape required.

The other problem with templates is "ink bleed". If the edge of the template is in contact with the paper/film, ink is certain to get under the edge. To avoid this, fix pieces of masking tape to the underside of the template slightly away from the pen contact

Fig.3.6 The reverse of Fig.3.5 showing the anti-bleed tape.

edge to lift the template clear of the paper. One or two thickness' will suffice. **Fig.3.6** shows an example of this technique. If the template is to be used for both left hand and right hand shapes it will need masking tape on both faces of course.

One minor problem is spacing such shapes on the drawing. In using the template to draw a line of shapes you find it obscures the previous one that you drew and also smudges the ink which is still wet. If you decide on the spacing first you can put in feint pencil divisions and safely do alternate shapes coming back to do the others after the ink has dried. In this way you avoid running shapes together because of the previously mentioned sighting problems and you also avoid ink smudge.

The use of coloured lines for half thickness etching

Two acetates will obviously be necessary – one for each side and these may carry different information. In the case of drawing board work the sheets are supplied to the etcher as hard copy, which he will then photograph to make the acetates (photo tools). Black lines and areas on the positive drawing will occur on both front and back acetates and will, therefore, etch right through (but it must be remembered that on negative drawings it is the black parts which are required and the transparent parts will be etched away). Red lines and areas on the artwork will appear only on the front acetate and will only etch half way through from the front surface. Blue lines and areas will only occur on the back acetate and will similarly only half etch from the back. Make sure that the red and blue lines do not coincide otherwise they will act like a black line and etch right through. **Fig.3.7** shows the two unpainted bridge structures exhibiting sharp folds and half-etched panels. **Fig.2.3** shows these parts finished and painted.

Fold lines are half etched in this way

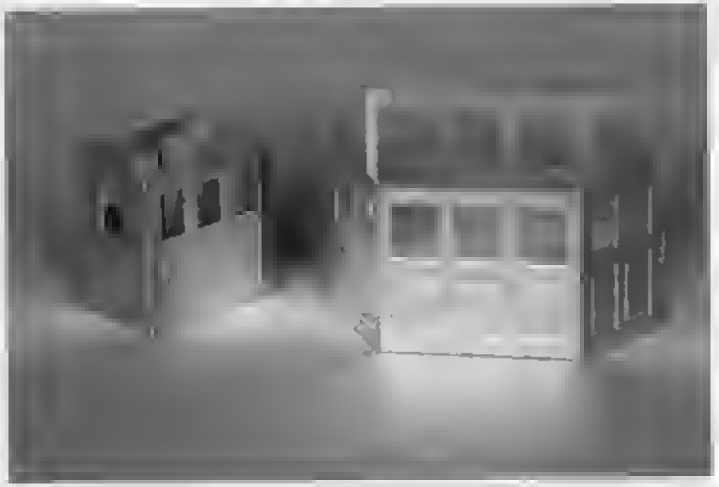


Fig.3.7 The main unpainted parts of the fore and aft bridges (HMS "Camperdown").

and enable tight folds to be produced. Fold lines should always be used if possible as it is easier to accurately locate them on the drawing rather than trying to do them "freehand" on the bench later. It also makes sharp bends very easy to do. **Fig 3.8** shows the use of thin red lines to half etch the planking on the deck of a steam launch. **Fig.3.9** on the other hand shows the use of blue lines for folding and half etching an area of the component. Unfortunately, as this book is not in colour, we have had to use light grey for red and dark grey for blue.

With orthodox artwork these red and blue lines will all be on the one drawing. Separation to front and back sheets is done by using colour sensitive film when your etcher makes the acetates. Before sending the artwork check that you have got the red and blue lines on the correct side. It may not matter if the parts concerned are symmetrical but if the components are handed in any way it most certainly will!

Also make sure the red is really red and the blue is light enough not to be seen as black by the camera. If in doubt send your etcher a sample for approval before proceeding.

Coloured lines can be done on both positive and negative artwork. However, on

Fig.3.8 Half-etched planking on the deck of a steam launch (1:100).

Fig.3.9 Area and fold lines half-etched on a component shown as dark grey.

negative drawings the black areas must be separated by the coloured lines, which makes the actual drawing more difficult.

The drawings are then sent to your etcher with instructions. He will want to know:

1. What material they are to be etched in?
2. What material thickness you require. You may need the same drawing etched in more than one thickness – say 0.004in and 0.008in.
3. How many etched sheets you require?
4. At what magnification, if any, the drawings have been drawn – x2, x4, etc.
5. Measurements of sheet border or any other datum lengths.
6. Do you want the artwork back?
7. Any other instructions?

Drawing for home etching

All the above has been tailored for producing fairly large drawings to be etched by an industrial etcher. The size of our etched sheet is usually 18x12in which explains why we use an industrial etcher. However, if you intend to do the whole process yourself the drawing you produce need only match your own requirements. For instance if you are only using one side etching, no colour work will be necessary and, no alignment problems will exist. You can produce a drawing on clear film using black ink remembering that the component you require must be black with the surround transparent and it must be to size. **Fig.3.10.** Also the other side of the sheet must be totally masked.

Alternatively you can draw the component larger than you need it and get your jobbing printer to reduce to the correct image size on his camera, but include a datum line of known length on the drawing to enable the size to be checked. Using a camera enables two identical copies to be produced so that you can etch from both sides but remember to include locating marks and getting both acetates lined up may be difficult.

Fig.3.10 A design for a test run using single-sided dish technique at home.

CHAPTER 4

PRODUCING ARTWORK USING CAD

The last chapter detailed the "drawing board" method of producing artwork. This is the method by which many will choose to work and to an extent it is perfectly satisfactory but, as has been said, manually drawn lines however skilfully drawn do not compare in accuracy and density with lines drawn with a computer. You do not require a very sophisticated computer but you do need a drawing programme.

We use TurboCAD and the following descriptions are based on knowledge gained from using this programme. There are other software drawing packages e.g. AutoCAD, CorelDraw, Micrografx Draw, HiJaak Draw which may use slightly different ways of arriving at the same drawing, but we have found TurboCAD ideal for our needs. If you are etching at home you will need a printer to produce the transparencies required for masking the metal sheets. You will need to take into account the sheet size and print quality.

We cannot go into the basic use of the computer in this book. You will probably need to attend a course to learn CAD. College courses may supply software cheaply so check before you buy it yourself. "CAD for Model Engineers" by D.A.G. Brown (No 29 in the Special Interests Workshop Practice Series) provides a solid foundation if you wish to remain independant. You can, of course, learn by persistence and sheer determination but this takes time.

However, we can discuss various techniques that you can adopt for producing suitable artwork and point out where you can go wrong!

Basically the computer has two aids to accurate drawing. One is the use of "snaps"; the other is using its geometric drawing aids.

The ones we use most are:

Snaps

1. The grid snap to snap to a point on the grid.
2. The vertex snap to snap on to the end of a line.
3. The nearest snap to snap to the nearest point on an object.
4. The midpoint snap to snap to the midpoint of a line.
5. The intersect snap to snap to the intersection of two lines.
6. The arc/centre snap for snapping to centres of arcs or circles.

(For accurate work these or similar tools **must** be used. If you do some of these operations by eye, inaccuracies will result. Do it freehand and then blow up your drawing to see why).

Geometric drawing aids

1. Parallel tool to draw parallel to an existing line.
2. Perpendicular tool to draw perpendicular to an existing line.
3. Tangent tool to draw a tangent to a circle or an arc.
4. Arcs, circles and ellipses can easily be drawn using the appropriate tools.
5. Bezier tool draws curves through any number of clicked points.
6. Spline tool draws the best curve through a number of points without going through every point.
7. Filleting and chamfering tools are available.
8. There is also a freehand sketching tool.

Editing tools

There are tools for lengthening and shortening lines, adding and subtracting areas, altering shapes of curves and splitting entities. Facilities are available for zooming in an out. This is where, if you have not used the snap tools, you can see your errors!

The other tools we use a lot are the copying tools – linear, radial and mirror. There are also facilities for rotating entities, rubber-stamping and hatching (filling in).

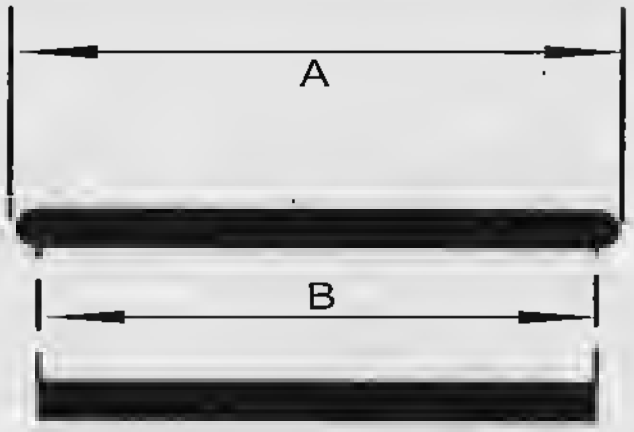
Measuring tools

There are various dimensioning tools for measuring lengths and angles very accurately provided you use the snap tool – no eyeballing the position!

Line width

When drawing on the computer, construction lines can be used as guides that show on the screen but you do not print. For lines to be printed, a line width must be set, but when a component is to be hatched

Fig.4.1 The influence of line width on overall line length. A is the actual length of the line plus the width, whereas B is the length required with no overrun because it has been drawn as a solid rectangle.



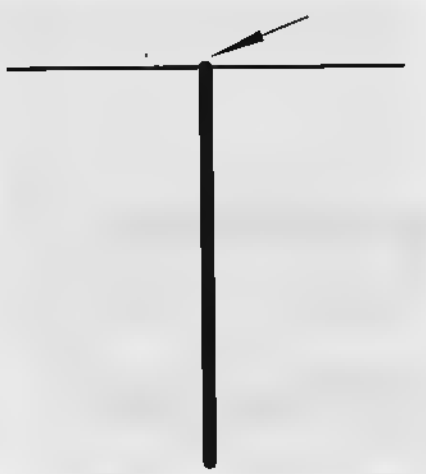


Fig.4.2 The arrow indicates the overrun, which may not be wanted.

construction lines or lines of zero width are used to avoid overrun. We will explain this phenomenon. A line of any width will be longer than its nominal length by the width of the line. This is because the ends will be rounded as shown in **Fig.4.1**.

With thin lines this effect is not very noticeable but with thick lines it can be unacceptable. This is shown in **Fig.4.2** where lines drawn in the form of a figure T clearly show the overrun. When drawing with a pen this effect is compensated for by the eye and the line is stopped short.

In a large number of cases this overrun of lines is of no importance, as it will lie in the waste anyway. However, there are cases where it is vital to stop the line where you want it and no overrun can be allowed. To avoid this problem it may be better to draw in blocks rather than lines e.g. instead of drawing a line 2mm thick using line width

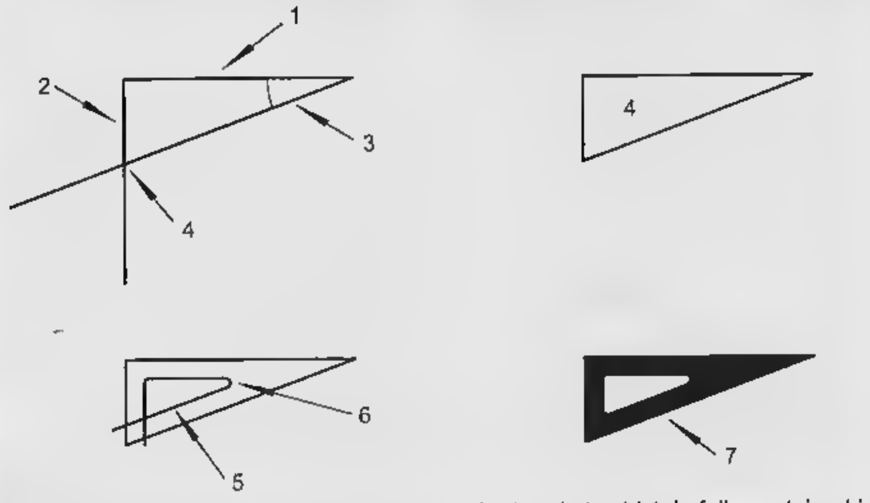
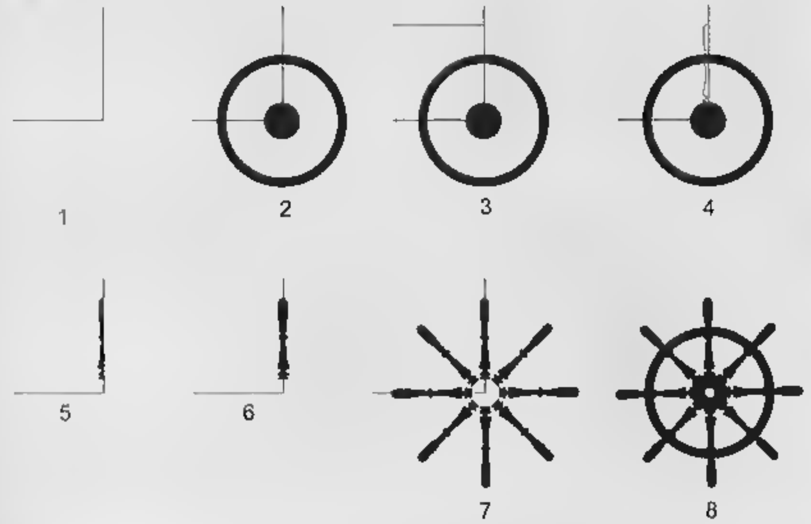


Fig.4.3 Shows the steps in drawing a triangular bracket, which is fully explained in the text.

Fig.4.4 The steps in drawing a ship's wheel (see text).



(2mm) draw a rectangle of width 2mm the same length. This will avoid any overrun. This is particularly important where little necks of solid material must be left. One example is when etching ladders (stairs) with "fold up" steps.

Drawing with CAD to produce the artwork for photo etching

The easiest way to show the basic use of CAD is to actually work through some examples starting with an easy example through to a difficult case.

Our basic technique is to start with a grid on the screen. This enables a point to be snapped on to the grid to give a basic starting point.

Drawing a bracket (Fig.4.3)

1. Snap to the grid with a line of zero width (length 50 angle 0).
2. Using the perpendicular tool, snap to left hand end of line using the vertex snap.
3. Using the line tool, snap to right hand end of the horizontal line using the vertex snap (set angle).
4. Using the line length tool the excess line length is snapped back to the intersect.
5. To insert the interior holes, use the parallel tool with an offset of 4 to draw the interior triangle.
6. The corners of this triangle are radiused using the fillet tool.
7. The part required now needs to be hatched (filled in). This is done et high magnification using the zoom tool and the hatch tool for solid black. (It may be that your CAD programme will hatch an indicated area or subtract one shape from another).

If you are using a colour printer you may find it easier to make the Interior shape

white on a solid black triangle or use layers to put one shape on top of the other. If the information is to be transferred electronically e.g. on a disc rather than hard copy, check with your etcher that he can read this information or whether he also needs hard copy to tell him that there are white areas present.

Drawing a ship's wheel (Fig.4.4)

To facilitate the drawing of this complicated shape we use construction lines. These can be easily seen and removed later. The zero line width enables accurate drawing, as there is no line width (over-run) to worry about.

1. Two lines at right angles will define the centre axis.
2. Using the circle tool, snap to the intersect and draw the solid hub and the annulus.
3. Using the parallel tool define the top of the spoke.
4. Using the bezier curve tool and snapping to the top intersect draw the left hand side of the top spoke. If necessary the curve can be adjusted using the node edit facility. (The hub and annulus are used as a spatial guide when drawing the outline and then removed to avoid processing unnecessary information).
5. Using the hatch tool fill in the left hand half of the spoke in solid black.
6. Using the mirror tool, mirror this half of the spoke about the vertical centre line.
7. Using the radial copy tool with the number of copies set to eight, radially copy the spoke.
8. The hub and ring are replaced to complete the wheel.
9. Remove the construction lines

Drawing a ship's ladder (stairs) with steps, not rungs(Fig.4.5A and B)

For items that consist of repeated units, such as a ladder, a grid can be constructed onto which a single entity (in this case a

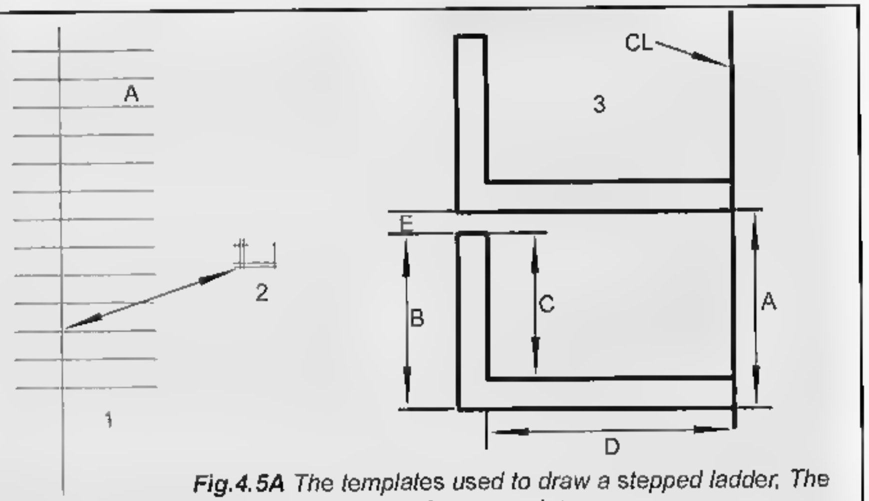


Fig.4.5A The templates used to draw a stepped ladder. The arrows indicate the reference points.

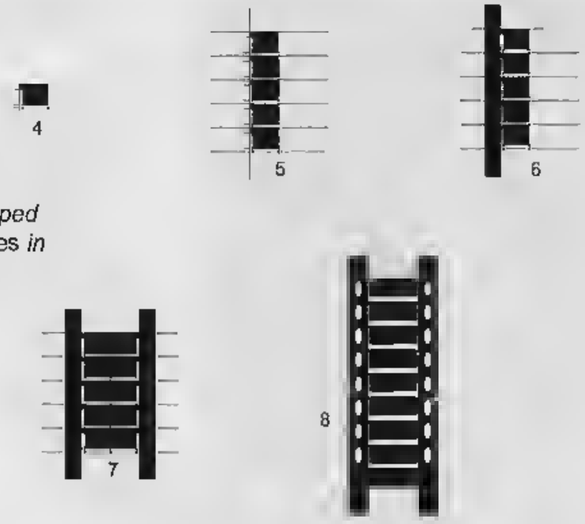


Fig.4.5B Drawing a stepped ladder using the templates in Fig.4.5A.

step) can be rubber-stamped.

1. Using line, perpendicular and parallel tools and zero width construction lines, draw a ladder template. The distance between the horizontal lines is the constant pitch between the steps marked "A".
2. Using the tools as in 1 above, draw a half step with construction lines.
3. An enlarged, notated view of the half step where:

"C" is the depth of the step which may vary according to the width of the stile and the angle of the ladder (think about it!).
"D" is the half width of the step
"B" + "E" = "A" which is the ladder pitch
"B" is controlled by the width "E" which is the neck joining the step to the stile (ladder side member). It is the most important dimension; if too small the ladder will break up, if too large the step cannot be satisfactorily folded up (we have found at 1/100 scale and sheet thickness of 0.008in a neck "E" of 0.3mm is O.K). It is important that there is no line overrun to reduce dimension "E" hence the use of zero width lines and hatching.

4. Shows the tread (hatched in solid black) defined by the etching border. At this stage a chequer plate design (taken from the computer hatch patterns) can be added if required.
5. Using the intersect snap tool, rubber-stamp the hatched half steps onto the original grid with the reference points coincident.
6. Using the parallel tool the outside stile line can now be added.
7. Mirror about the vertical centre line (CL).
8. To complete the ladder the ends of the stiles can be finished off and lightening holes added if required. The construction lines do not print or transfer electronically.

This is just one way of drawing a ladder but you may develop your own style

Fig.4.6 A completed but unpainted accommodation ladder.

according to the CAD programme you use. **Fig.4.6** shows a folded and soldered ladder, which had to be painted before fitting to my model of HMS "Camperdown".

Linear copying

As well as radial copying, described above, CAD can also copy linearly. **Fig.4.7** shows the etching drawing for one part of the ornamental guard-rail around the top of RN "Duillo's" accommodation ladder. In this case the total length of the guard-rail required can be calculated and the computer used to copy the small section linearly. **Fig.4.8** shows the final etching drawing with the repeated pattern forming the total length of guard-rail, which is then fitted to the top platform (this has also been etched with locating holes).

Rubber stamping

With the design completed and checked it can be repeated "n" times by using the "rubber stamp" tool and then placed where needed on the etching sheet.

Rearranging

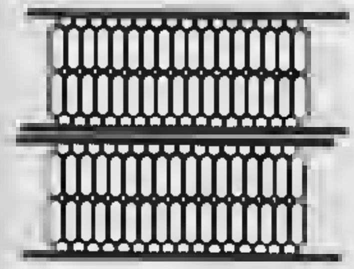
CAD also allows the moving of components to get maximum utilisation of the sheet. This is most useful as it is very difficult on the drawing board to rearrange parts on a drawing easily.

Producing front and back sheets for industrial etching

Before commencing your drawing you will need to decide whether to draw in two layers or to duplicate the sheet and alter the information to produce a front and back sheet. You need to end up with a front copy, where all the parts that are half etched from the front are shown in white, and a back copy where all parts that are half etched from the back are shown in white. On both sheets the black areas will remain after the transparent (white) areas have been etched away. This can be done directly using the layer technique. Layer one becomes the front sheet and layer two the back sheet. In this way the computer can separate out the two necessary drawings.

Fig.4.7 Drawing of the repeating section of the Victorian pattern ladder screen.

Fig.4.8 The item shown in Fig.4.7. linear copied and mirrored to form the screen.



As work on the model build proceeds it becomes apparent which parts need to be etched and we find it suits our way of working to design and draw these as they occur. We draw one copy of each part to exact dimensions, with all the information on the drawing: number required, half etching front and back, identity number of part, any instructions, etc. **Fig.4.9.** At this stage we use colours to denote front (red) and back (blue) half etching leaving just one copy on the sheet unless mirrored copies are required. In this case we produce one mirrored copy and put all the information on it as above **Fig.4.10.** We do not rubber stamp anything or arrange it on the sheet until we have enough to fill it. This process may last several months, so it is very important to label everything and keep a list of these components with their identity. If they are part of a structure, note exactly where and what, their position is on the model, etc. as it is very easy to forget what they are.

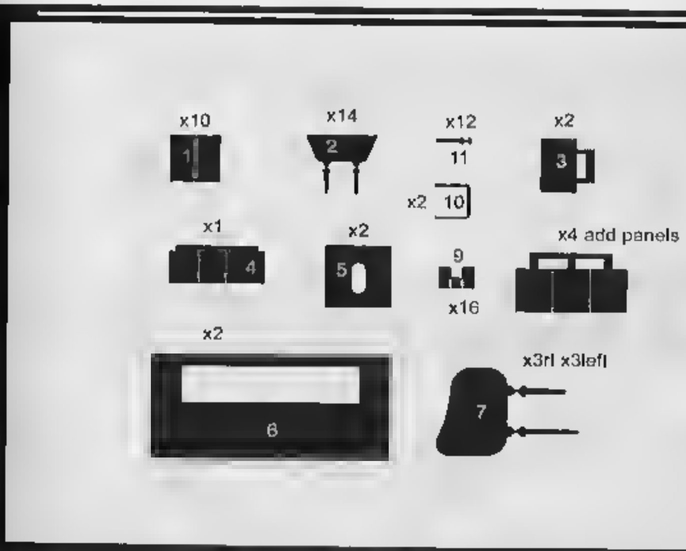


Fig.4.9 One copy of each of the components to be etched with all the necessary information. The note to add a panel on part 8 was an aide memoir. Note the dimension datum line on the frame that defines the sheet size.

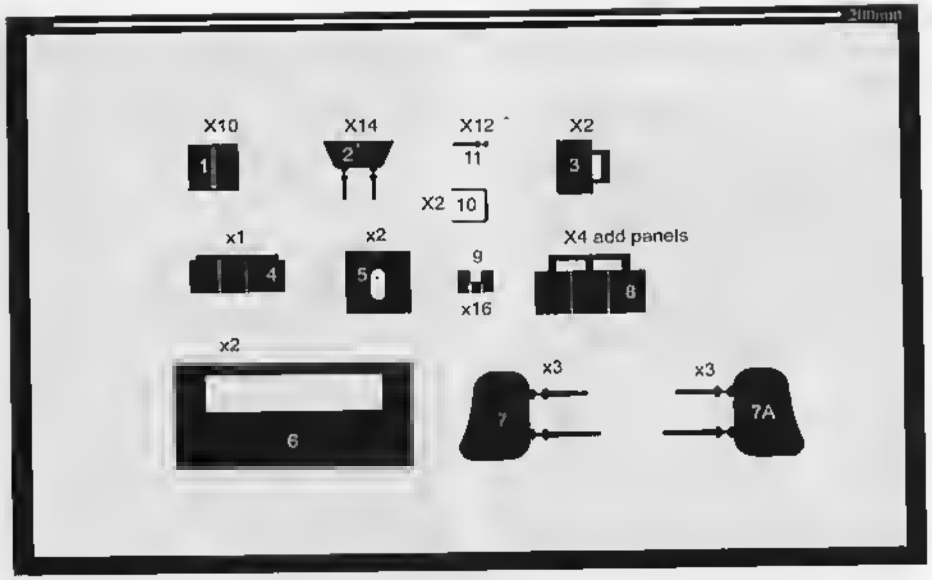
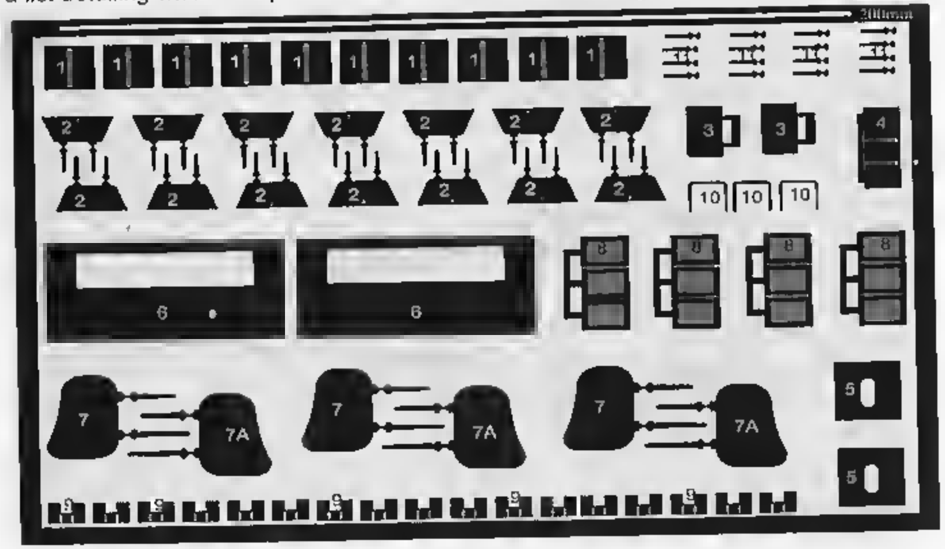


Fig.4.10 Component 7 has been mirrored as it is handed and 3 of each are needed.

Below: Fig.4.11 The printed sheet to be kept for part identification. This will match with a list detailing where the part fits on the model and any other information.



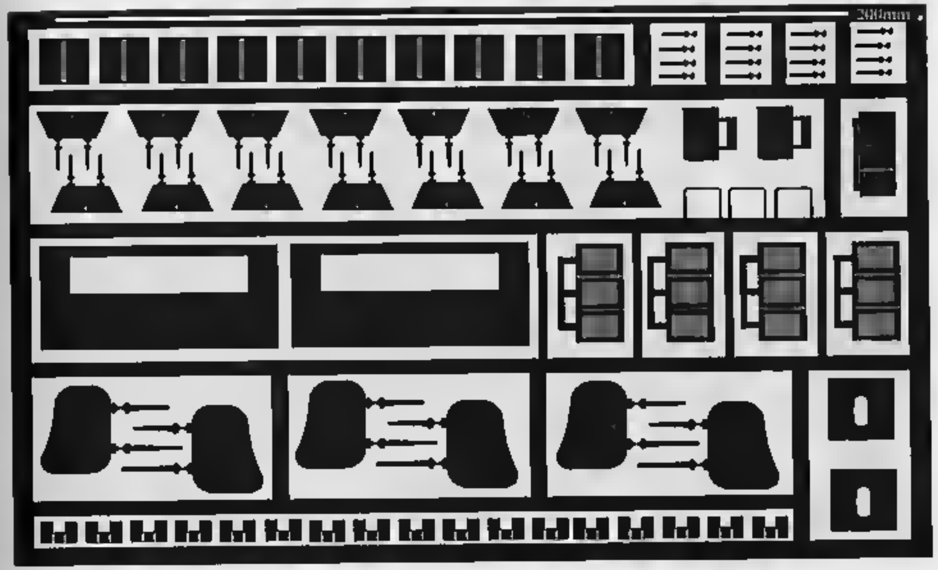


Fig.4.12 The sheet with text removed and main matrix added. Note that delicate parts have more copies than are actually required to cater for wastage. Also the half etched panels have been added to Part 8.

When we have enough parts to fill a sheet we "rubber stamp" the components until we have the correct number of each and then arrange them on the sheet. At this stage a printout on paper is made so that the parts can be identified when the etching comes back from the etcher **Fig.4.11**. With the part number on the component it is always moved or copied with that part, thus ensuring no mix-up. The text is then removed from the drawing and the main matrix constructed to stabilise the sheet. **Fig.4.12.** When we are finally satisfied with the layout we copy the sheet giving us a front and back etching sheet. (You will note that the components are black – the etcher will use this information to produce the acetates [photo tools] using his X,Y printer).

The last step is to take the front sheet and make all the areas to be half etched from the front (red in our case) colourless and all the areas to be etched from the back (blue in our case) black. On the back sheet the red areas are made black and the blue areas colourless and the connecting lines are drawn. **Fig.4.13A** and **B.** (**A** is the front sheet and **B** is the back sheet).

Electronic transfer to an industrial etcher

The information produced above can be transmitted electronically – by floppy disk, CD, DVD or email. It is essential that you can transmit your information in a form that he can read. For example TurboCAD files are .TCW, AutoCAD files are .DWG or .DWF and CorelDraw are .CDR. There are programmes that can convert one file type

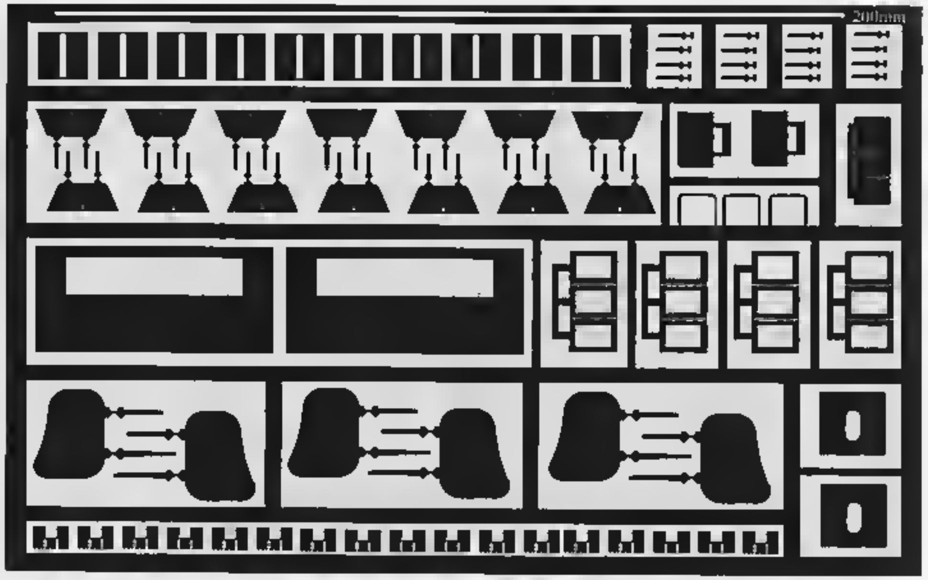
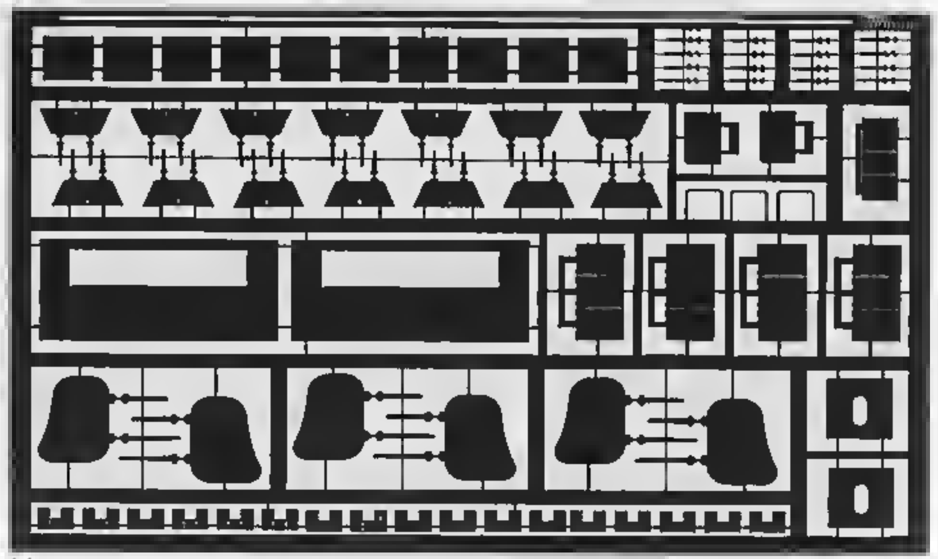


Fig.4.13A The front sheet as sent to the etcher.

Fig.4.13B The back sheet as sent to the etcher.



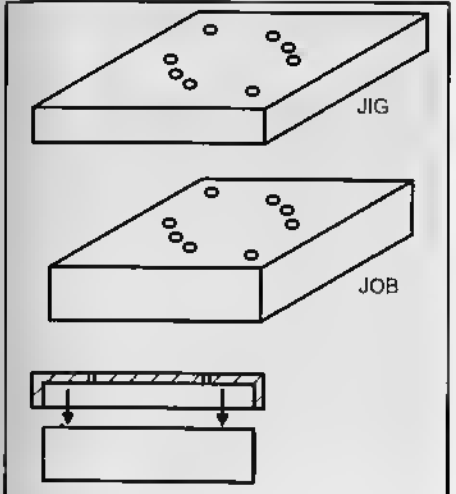


***Fig.4.14** Isometric drawing of jig, which did not satisfactorily transfer.*

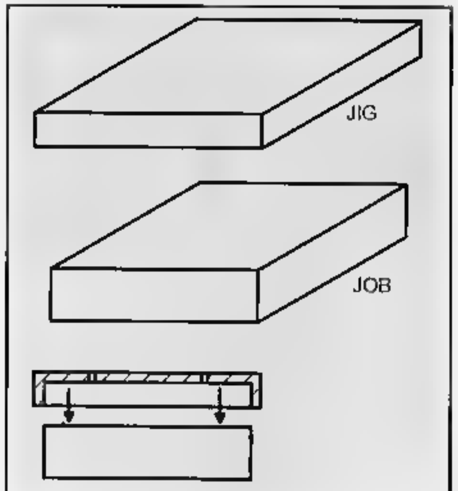


***Fig.4.15** What was actually received when Fig.4.14 was transferred.*

to another or you may have a choice as to which file type you save your information to. These transfer systems are not always reliable and some still need the bugs ironing out so you must check that ALL your information has been transferred correctly. Line widths, for example, are created in different ways in different programmes and they may not transfer from one file to another. With etching drawings, the line width is very important so be sure to check that what your etcher is receiving is what you think has been sent. We avoid line width problems by drawing all our components as blocks or hatched (shaded) areas. This information seems to transfer more easily and we find less mistakes. Send hard copy of your drawings with the disc so that the etcher can check against them. They need not be to size but it not, do tell the etcher. You can produce large sheets by using the tiling facility on your computer if you need a full-size copy.

In the early days of electronic transfer of drawings we tried to send a .TCW drawing which we had stored as .DXF as the recipient could only read .DXF files. **Fig.4.14** shows what we thought we had sent (the original) and **Fig.4.15** shows what was actually received. You will note the holes shown as ellipses (because the drawing was isometric) did not appear, so the whole object of the illustration was lost. Unfortunately the recipient was unaware of the omissions - it only came to light accidentally. We can only say that electronic transmission is possible but it can have difficulties!

The only sure way is to send hard copy that you have checked, for comparison by the etcher, until you are sure all the information is "getting across". It can be an expensive mistake.

We have also found that the font

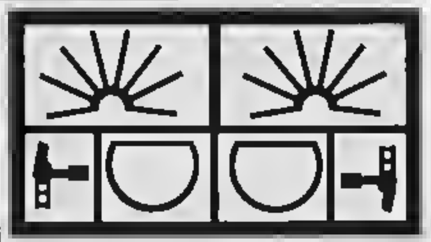


Fig.4.16 A front etching sheet.

changes with software and you will need to provide a hard copy of any text you need etching e.g. nameplates.

Producing a front and back sheet for home etching

We find it difficult to handle large sheets for home etching and have only an A4 printer so all large sheets are sent to an industrial etcher. However, there is always the time when you cannot wait for the large sheet to be completed or you have left something off.

So, for small, urgent jobs, we produce the drawings and print the sheet(s) on transparent film. In this case we have to produce a transparent sheet with the components in black. If half etching is required a front and back sheet must be produced again with the required parts drawn in black and the parts to be etched away transparent. **Fig.4.16** shows a front sheet ready for home etching and **Fig.4.17** shows the back sheet with the connectors. Note they are mirror images as the ink on the transparency needs to be next to the metal sheet for maximum resolution. It is imperative that the front and back sheets are accurately lined up. It may be helpful

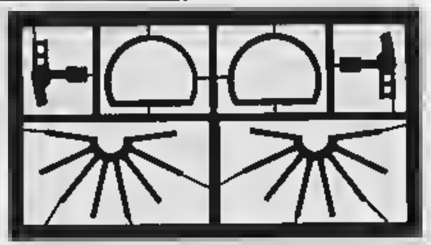


Fig.4.17 *The same components as in Fig.4.16 but with connectors making the back sheet.*

to put lining-up marks on both sheets for this purpose in which case put these marks as wide apart as possible to get maximum accuracy.

Using computer accuracy to fit parts together

When preparing artwork the problem of fitting parts together is likely to occur. For instance, "built in" ladders often exist on the side of hulls, funnels, caravans, railway coaches, etc. These consist of separate rungs fitted or welded directly to a surface (hull side or whatever). Normally, making these presents problems of accuracy. If they are made by fitting wire rungs into holes, the usual method, the holes must be accurately drilled for position and the wires bent to give close control of the leg centres to fit into the pre-drilled holes. Perhaps the best method and most accurate is to make a drilling template using, if possible, a milling machine to index the holes. The alternative of carefully marking out and drilling is usually not so accurate and certainly more time consuming. Accuracy with this sort of detail is a must.

The accuracy of CAD can be utilised

here. A drilling template can be etched to enable the holes to be drilled. **Fig.4.18** shows an etched template for drilling the hull to fit an offset ladder around the base of a mooring boom. One rung can then be drawn to fit accurately into these holes. The computer can be used to check both the centre distance between the legs and the hole pitch. Any number can then be rubber stamped from this one, correct rung. It must be emphasised that when the computer is used to check dimensions, the snap tool is used to ensure the computer is looking at the correct point. Freehand spotting by the cursor is not good enough.

Storage of standard components

Certain components become standards that you use again and again e.g. stanchions of which there can be several types even on one vessel. Components such as these should be stored for future use. Remember they can easily be scaled so you can make them fit the scale being used.

Fig.4.18 *Drawing for a drilling template.*

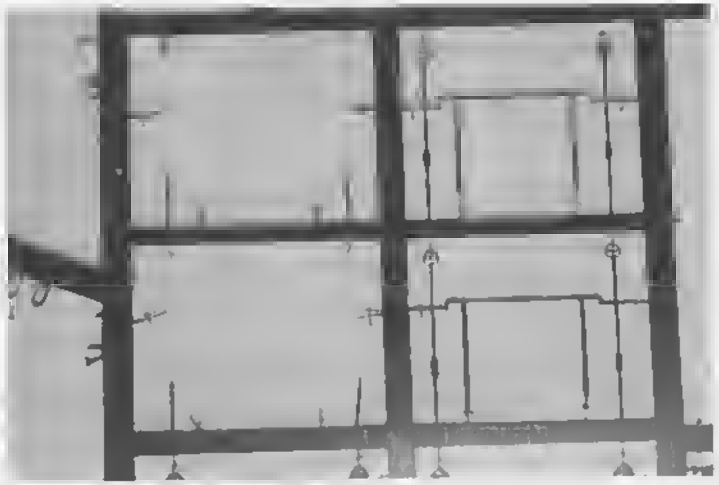
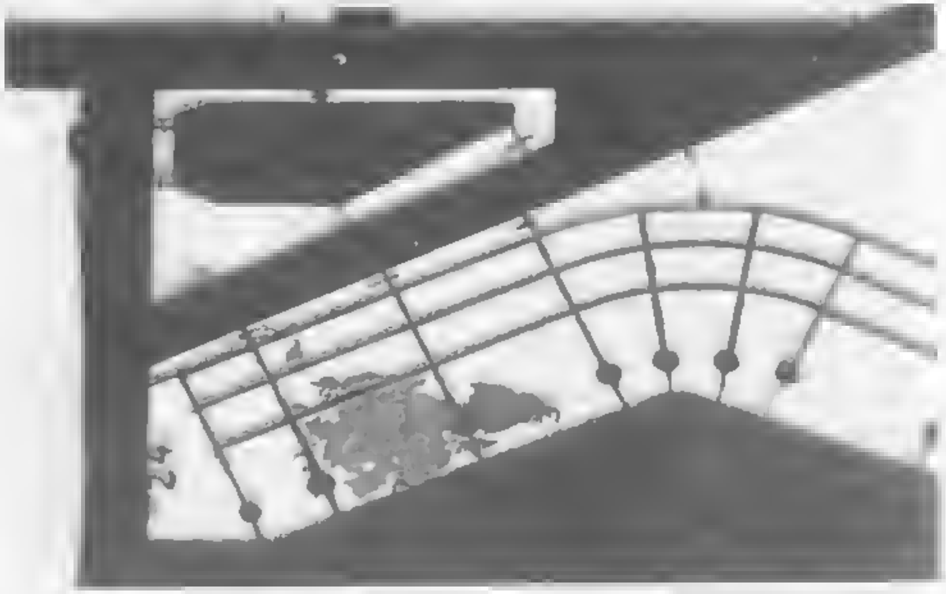


Fig.5.1 *Parts etched out.*

Fig.5.2 Under etching with superfluous material (in practice this could be easily removed with a scalpel).



CHAPTER 5

COMPONENT DESIGN

Limitations of the process

As was discussed in Chapter 2 the limitations of the whole system must be kept in mind when designing parts for etching. It is no good designing parts that will fail, for one reason or another, to see the light of day. One case discussed was the design limitations of fine grids and lines. The lesson is clear: do not push the system beyond its limits. There is always a desire to try and get finer and finer detail but you can go too far!

Troubles you may encounter

There are several faults that occur fairly frequently. **Fig.5.1** shows some delicate gun sights have been etched away probably because the lines were drawn too thin. **Fig.5.2** shows a case of slight under-etching leaving some partly etched material in the matrix. This may be a nuisance in production etching where clean etchings are required but, for the "one-off" model maker, a moment's work with a scalpel is all that is required to remove the offending pieces.

Assembly aids

When designing artwork you must remember that the drawing is only a means to an end and the resultant etched part is what you are really after. The parts have to be handled and assembled afterwards. Do not forget therefore to add any holes or assembly tags. For instance, a cylindrical object developed into a flat area may need an extra strip on the edge to secure it as a cylinder. If you merely develop the cylinder how do you fix the butting edges? How are you going to fix the piece down or to another piece?

Locations

With a little forethought assemblies can, and should, be made self-locating. The etchings of the doors for a fairly large scale (1/25) model are shown in **Fig.5.3**. The door is shown as a front sheet etching drawing, thus the white lines will be half etched from the front giving the effect of planking. The half etched location holes for the door furniture match the holes in the key plate, which was drawn as a positive etching drawing. This enabled self-locating assembly.

Without the holes the location of the key plate would have been more difficult and possibly less accurate. It is always

Fig.5.3 Self locating door plate.

easier to cater for locations at the drawing stage rather than on the bench.

Mock-ups

The whole art of using etching as a modelling tool is far more cerebral than working on the bench with physical parts. In the later case you can see, or try, the fit of the parts. Using etching you only have thought to play with! – no parts exist except in your brain! It is always a good idea to cut out the parts in card or paper and see if they fit. **Fig.5.4** shows a card cut-out of a funnel gantry.

Better to find any changes required before the expense of etching. .

If there is any doubt about a shape or design mock it up first. Check your developments the same way. With the part in your hand, you can often see how it could be improved and that you have missed something when you developed a 3D shape to a 2D drawing for etching. For example things like deckhouses usually have four sides which form up with three half etched fold lines: But how do you join the two ends (the fourth corner)? Do you butt solder them? Are you that skilled? Otherwise do you need a tab on one end or will you require a separate angle piece to solder the two ends together? These are questions you must ask yourself when designing components. It is all too easy to just design the part and ignore the assembly and fixing. It is always too late when the etched part is in your hand! Remember also that any extra bits you have added can always be cut off if deemed surplus when you finally get round to assembly. The converse does not apply however.

A useful material is cereal box cardboard, which should be in generous supply in most households. Just do not throw it away but store it in your workshop and use it to cut out templates and "try-outs" first before using expensive material. It is surprising what a few "cut-outs" can achieve in saved material or as a catalyst to better ideas!

Aluminium litho plate can also be used. It has the advantage of being "dead" – it retains folds – unlike paper and card which retain their springiness which can be very annoying. Aluminium litho plate is fairly easy to obtain from your local jobbing printer. It is a most useful material in many

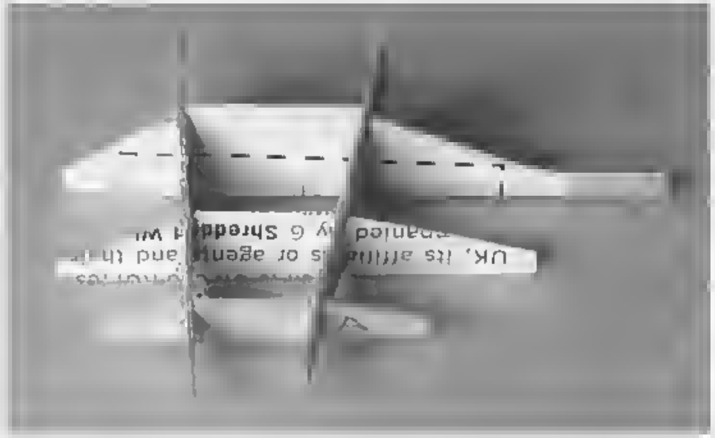


***Fig.5.4** The etching drawings being proved by a cardboard cutout.*

ways although soldering can be difficult unless you have the proper solder and flux – particularly the latter. **Fig.5.5.**

Half etching

Fold lines

Fold lines should be stopped short of their ends, by about 0.5mm, to give a short length of full thickness. This is to avoid the fold line "tearing". Ends of fold lines tend to over etch as the etchant can get at the metal from a number of directions at this point. This short length of full thickness has little detrimental effect on the bend.

Etching from both sides means, of course, that the two acetates must be accurately registered but that is the responsibility of your etcher. We usually draw fold lines 0.2 to 0.3mm wide. If in doubt ask your etcher what minimum line

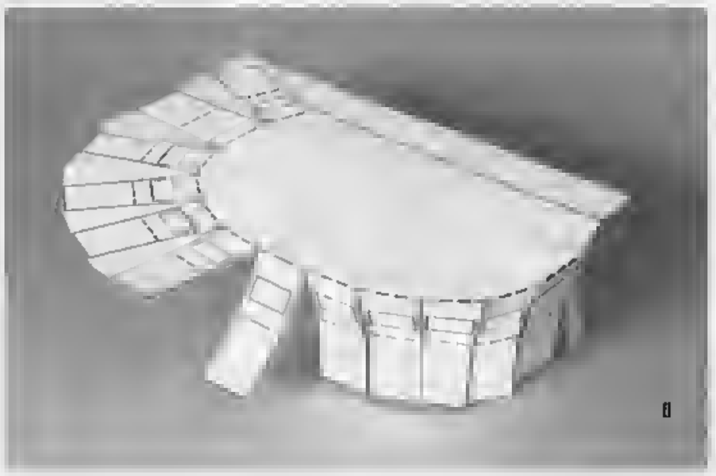


***Fig.5.5** This litho test piece was developed to show the shape of a Type 22 destroyer's bridge. The metal is covered with a sticky backed paper version of the CAD drawing.*

Fig.5.6 *Etching drawings for Duilio nameplate.*

width he would recommend or, if home etching, experiment to find the limits of your system. The minimum line width will obviously depend on the thickness of the metal as well as the etching process.

Raised and sunken areas

As well as fold lines, areas can be etched away to leave say: a row of rivet heads, strengthening ribs on the sheet metal sides of vehicles or name plates for locomotives. **Fig.5.6.** shows the back (above) and the front (below) sheet etching drawings for the nameplate on RN "Duilio's" hull. Nameplates on ships consist of raised letters that are painted or gilded. Etching can be used to produce these. Using a suitable typeface selected from the computer's banks (or drawn out to suit the original) these can be half etched onto a suitable rectangle of brass. This will leave the background very thin. The whole surface can be sprayed hull or superstructure colour. If the original letters were gilded they can be cleaned off and lacquered. Otherwise they can be painted another colour. A competent model maker should be able to "lose" the thickness of the background if required, when the plate is fitted to the model. Alternatively the letters could be etched-in and the resultant depression painted. Another method would be to etch a template for spraying but problems with enclosed letters may rear their ugly heads and a stencil font will need to be used. You really are spoilt for choice.

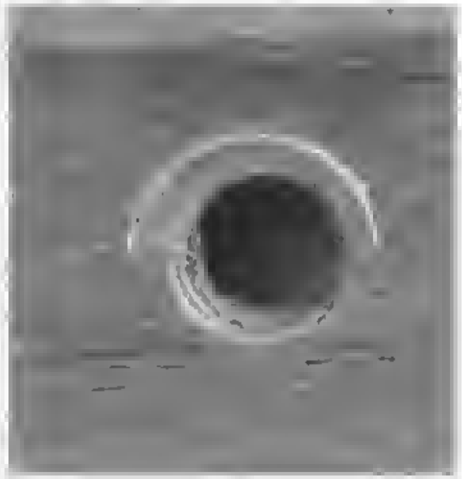
Trompe d'oeil (deceiving the eye)

On very small work ribs, rivets, etc., can be etched-in rather than exposed by area etching, leaving them proud. This technique is really cheating but for small objects it works well and produces a more robust component.

The rigols (eyebrows) as well as the portholes, on my model of HMS "Camperdown", were etched into the brass hull side facing etchings. The rigols were only half-etched but the eye sees them as standing proud because that is what you expect to see. **Fig.5.7.**

Simulation is the name of the game in modelling anyway!

Fig.5.7 *An example of a porthole with an etched in rigol.*



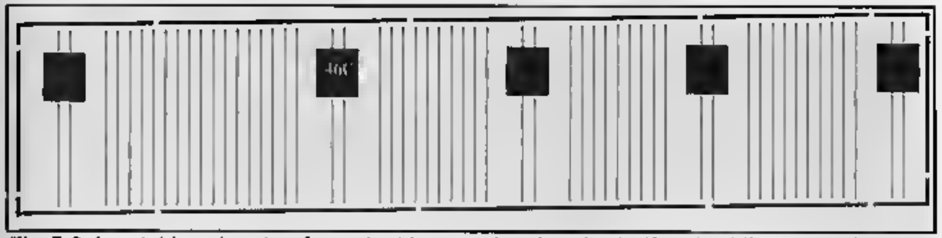


Fig.5.8 *An etching drawing for a deckhouse showing the half etched lines (grey) to simulate the V-grooved planks.*

Adding detail

Half-etching can also be used for putting panelling and planking on wood deckhouses, carriages, etc. Usually deckhouses have glazing in the top half of a panel whilst a similarly shaped wood panel exists on the lower half. This may consist of a plain panel or just a panel with a border. The glazing can also have a reduced border around the glass. All these features can be half-etched in.

The side panels of the deckhouse on RN "Duilio" consisted of vertical planks with V-shaped vertical joins between them. Again ideal etching detail. With a long run of vertical planking interspersed with doors the computer can be used to divide up the lengths by linear copying. **Fig.5.8.**

Compound parts

When designing the drawings it may be easier to join parts together at this stage rather than trying to handle and assemble many pieces.

Guardrails and Handrails

If the scale is small enough guardrails can be etched, be they the pipe variety or chain hung. The giveaway when looking at photos is that pipes do not sag and do not require stanchions in the corners **Fig.5.9.** Chain, when hung between two stanchions will hang in a curve known as a catenary which, for practical purposes can be drawn as part

Fig.5.9 *Drawing for pipe-type guardrails.* ***Below: Fig.5.10*** *Drawing for chain type guard-rails. Note the angled support stays at each end.*

Fig.5.11 The appliquéd deck edge with the holes drilled for the guard-rails.

of a circle. On the computer use the curve facility **Fig.5.10**.

Lengths of guardrails can be etched with the spacing of the stanchions made to fit the deck edge. They are not usually equally spaced, as they have to avoid fairleads, davits, bollards, etc. all of which have to share the deck edge. Unlike bought out standard items they can be tailored to fit a specific length of deck edge and must be identified as such. You also need to mark the forward end so you will not attempt to fit it back to front. It has been done!

The length you etch is dependant on what you can handle as lengths of guardrails are very flimsy. If you half-etch the "chain" they will be even more delicate. The stanchions are usually tapered with two or three balls. If you are using a computer, design a stanchion and save it. Don't forget the sloping members supporting the end stanchions (and possibly some intermediate ones) against the pull of the chain. They will also need an extension on their lower ends to fix them to the deck and, if they are of the wood-capped variety, a tag on the top ends as well.

If you cannot span the length required with a single piece then two or more pieces will have to be joined together. To do this without ending up with an unsightly mess, half-etch the end stanchions e.g. half-etch the rear stanchion on the front and its mating stanchion on the back. Carefully joining these should make the joint invisible.

Design and fitting of tailored guardrails

Whether you use custom built guardrails or bought-in ones they have to be fitted. One way is to drill the end hole and then subsequently drill the remaining holes in succession marking and drilling the holes using the guardrail strip as a guide. This has problems and requires good judgement and a steady hand to get each hole correctly spaced from the last one. Some thought was given to this problem, which resulted in drilling the holes first and using the computer to measure the

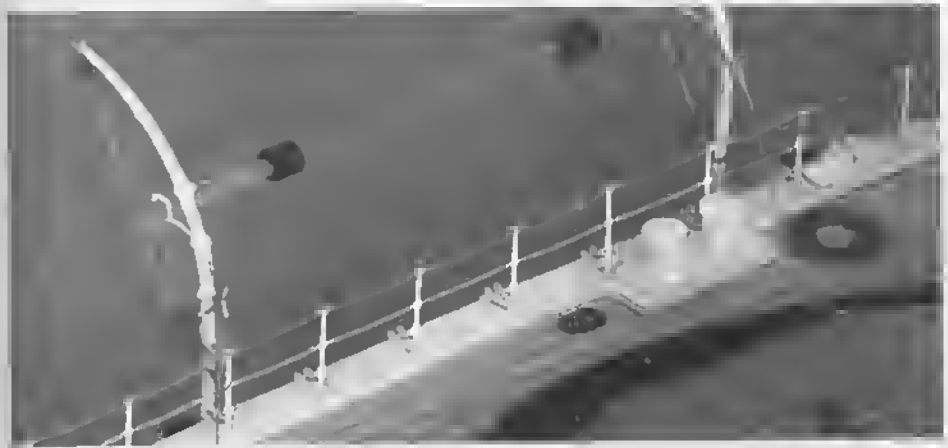


Fig.5.12 The guardrails fitted and painted. Two coats of white paint were applied to the stanchions to make them appear round and the "chains" were painted dark grey.

distances between holes and making the etched guardrail strip to suit.

The ship in question had a separate deck edge applique, which was marked out and drilled. (**Fig.5.11** shows the deck edges drilled and fitted to the hull.) This was scanned into the computer and checked for size. A bezier curve was drawn through the holes and each space was measured along the curve. This was done even if the guardrails we were simulating were of the chain type but this needs explaining. Because the railings were to be made of brass shim (not chain) they naturally took up a curved shape when bent round between the holes. At first thought the spaces should be measured as chordal dimensions (that is a straight line between holes) but this practice leads to stanchions being too close together. Always err on the full side as you can usually loose a few thou' too much but not vice versa. Construct a grid to these dimensions and snap the previously drawn stanchions onto each intersect. The connecting members (either catenary chain or straight pipe) can then be added. We found assembling this way very easy. You can spray the guardrails dark grey when still in the matrix and paint the stanchions white afterwards. Two coats, applied with a brush, will give you more of a "round" look to the stanchions **Fig.5.12**.

Different ways of approaching component design

1.Grid in a frame with rivet heads showing on the frame

As can be seen from **Fig.5.13** these were a type of ventilation shaft cover consisting of a frame surrounding a grid with rivet heads showing on the frame. To show the rivet heads the frame was to be half-etched.

Drawing board method

(a) The grid was first drawn in black together with the rivet heads. To avoid over etching the rivet heads, they were made slightly over size. The frame area around the rivets was coloured red (light grey in **Fig.5.14**).

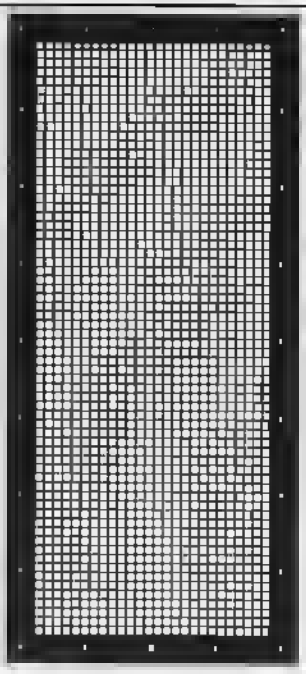


Fig.5.13 *A grid and frame with exposed rivet heads.*

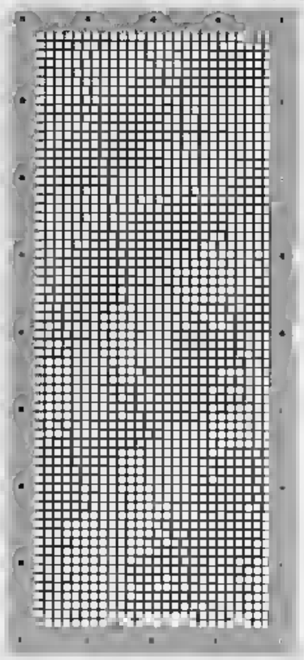


Fig.5.14 *Frame with full thickness grid.*

Half-etched lines were also required to hold the part into the matrix. The above will give you half thickness frame with full thickness rivet heads and grid.
(b) If a half thickness grid is required then it must be drawn in red **Fig.5.15.**

Using CAD

(a) The drawing for the back acetate will comprise the grid, the frame and the connecting lines.
The front drawing will only contain the rivet heads **Fig.5.16.**
(b) For a more robust job the frame and grid could be etched as one part (everything full thickness) and another part etched comprising a half-etched frame with full thickness rivet heads. This second component could be appliquéd onto the first. See **Fig.5.17** where the front sheet is on the left and the back sheet on the right (note the connecting lines on the back sheet only).

2.Turret skylights

Eight were required. This problem emphasises how much thought is really necessary with complicated parts and how many variations there are to a problem. **Fig.5.18** shows part of a glazed skylight with protecting bars (18 of these bars were required for each skylight).
Method 1 The orthodox method would be to cut, file and drill out the plate and use

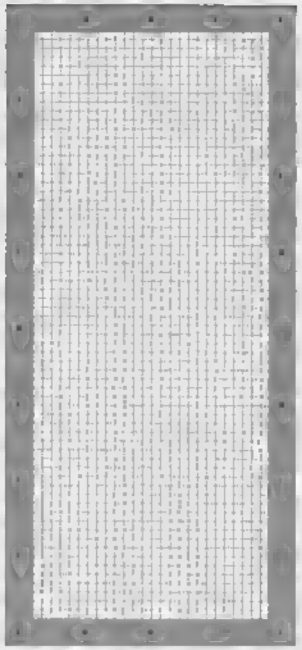


Fig.5.15 *Frame with half thickness grid.*

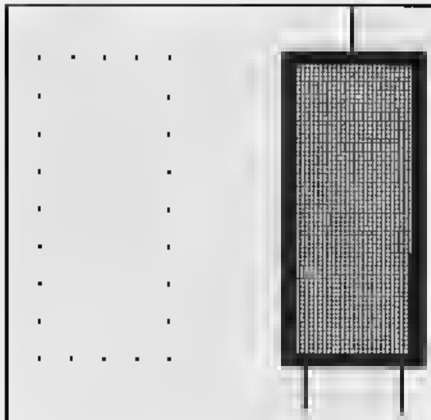


Fig.5.16 *Front (left) and back (right) drawings for half thickness grid and frame with full thickness rivets.*

bent wires for the bars. (**Fig.5.19** shows the cross section of this technique). All very difficult, time consuming and inaccurate. Bending and securing wire into accurate "U" shapes is not easy and 144 would be required! Accuracy with this sort of detail is

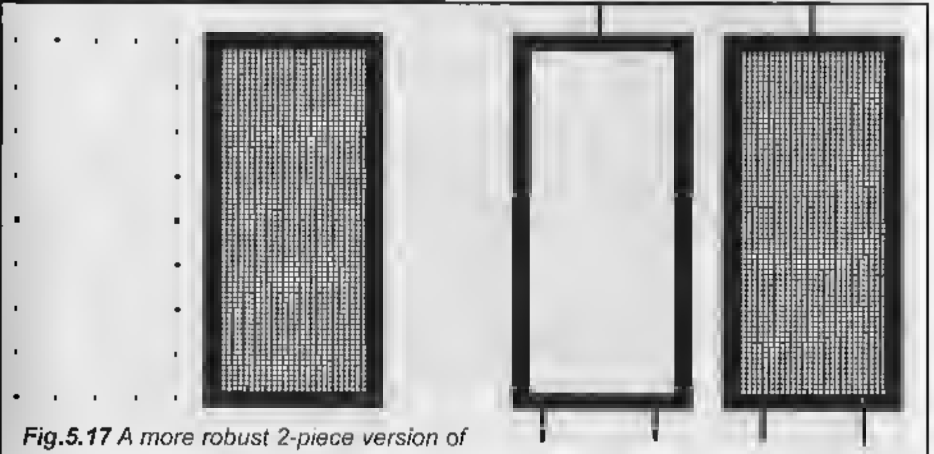


Fig.5.17 *A more robust 2-piece version of Fig.5.16. See text.*

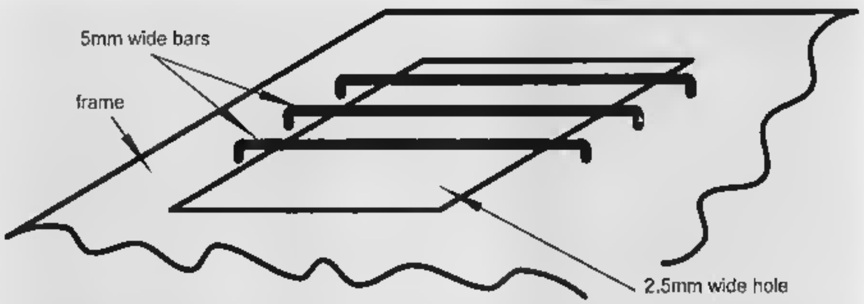
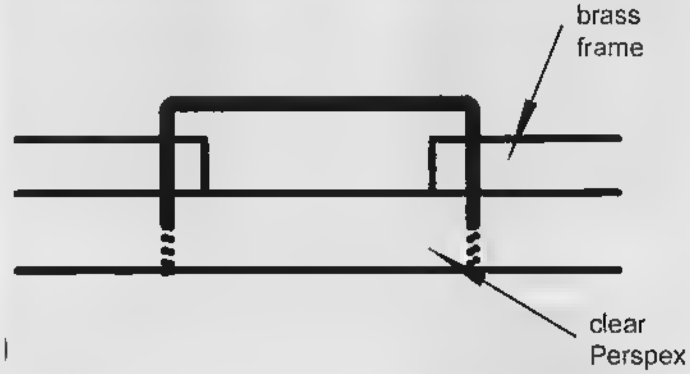


Fig.5.18 *Part of a glazed skylight with protecting bars.*

Fig.5.19 *A cross section of a skylight built without the use of etchings.*



an absolute must otherwise they will stand out like sore thumbs.
Etching is the most satisfactory solution to the problem.

Method 2 The next step would be to etch the plates complete with the bar location holes and etch the "U" shaped bars instead of using bent wire. This would produce a more accurate job as you can use the computer to measure both the distance between the locating holes and the ends of the legs of the bars. Fig.5.20 shows the etching drawings for one side of the skylight (originally drawn x2 on the drawing board). From actual experience the problem is one of assembly. The original idea was to fix the plate to a Perspex block of the same external dimensions, drill through the holes and drop in the bars. This would have provided stability to the bars. The problem remained that the Perspex "glazing" could not be masked off for

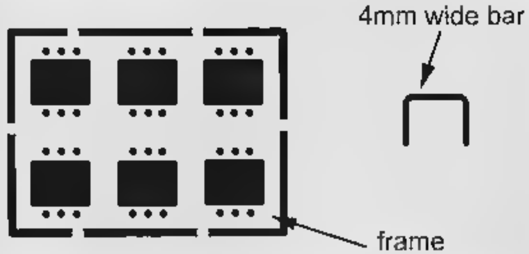


Fig.5.20 *Drawings for one skylight and one bar.*

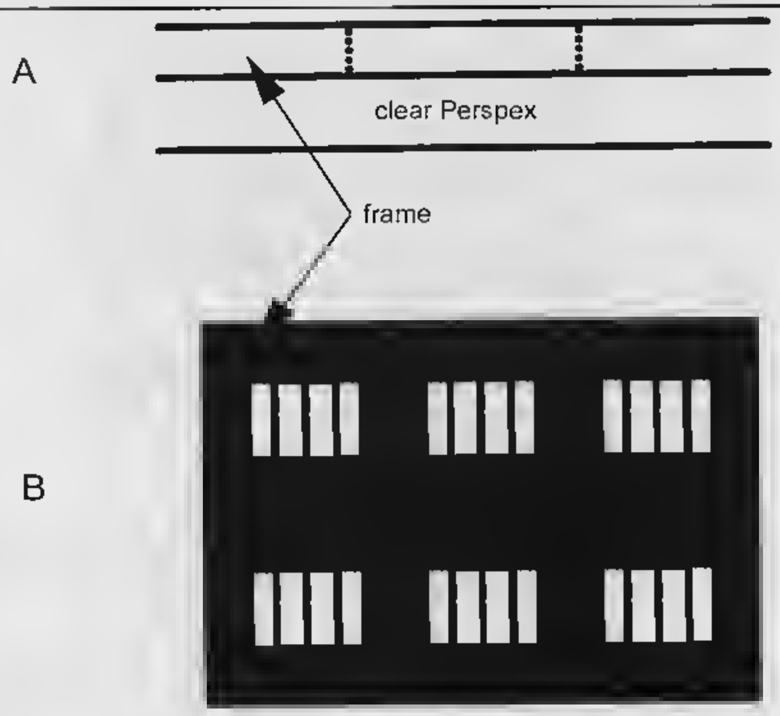


Fig.5.21A *Shows a cross section of skylight and bars all etched full thickness.*
Fig.5.21B *The drawing for the flat skylight.*

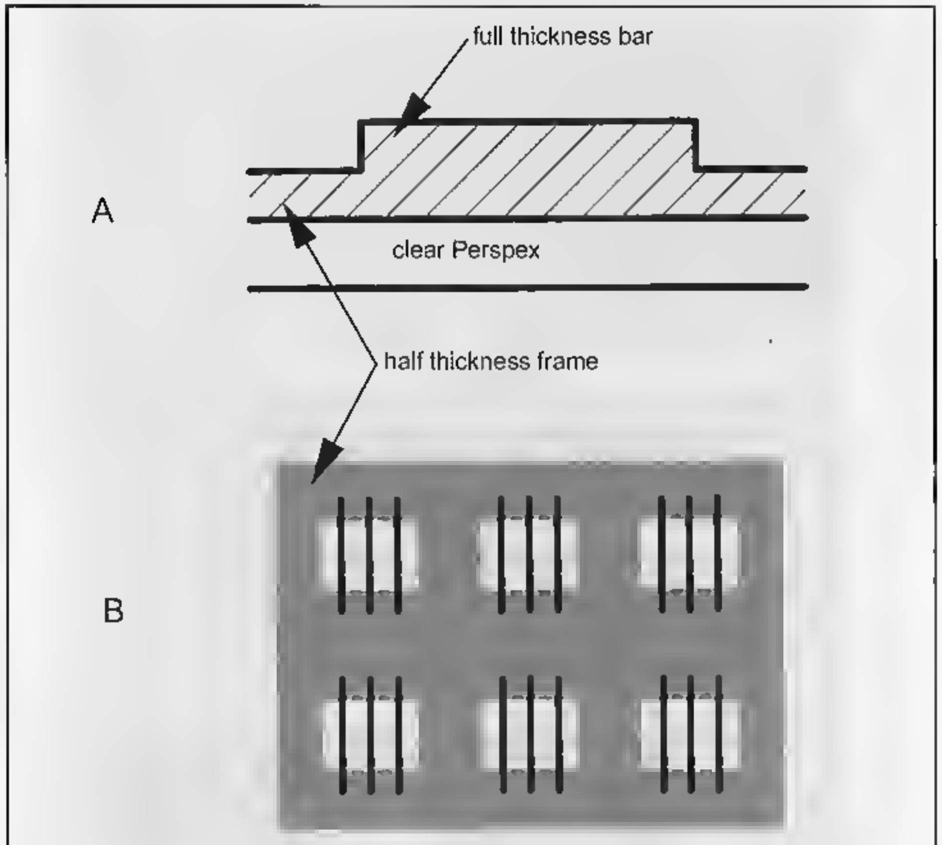


Fig.5.22A *Shows the cross section with raised bars.* ***Fig.5.22B*** *The single etching drawing to achieve* ***Fig.5.22A.***

painting. No way round this could be seen so an attempt to solder the bars without using the Perspex block was made. However, without the depth of hole provided by the Perspex, the "U" shaped pieces simply took up random positions.

If you draw x2 you get a distorted idea of how big (or small) the component really is. The above example is a case in point. If the component had been as large as the etching drawing (x2) each bar could have been soldered in separately and no problem would have existed.

So what other alternatives are there?

Method 3 The simplest way would be to etch the bars across the holes producing a flat component of constant thickness. This

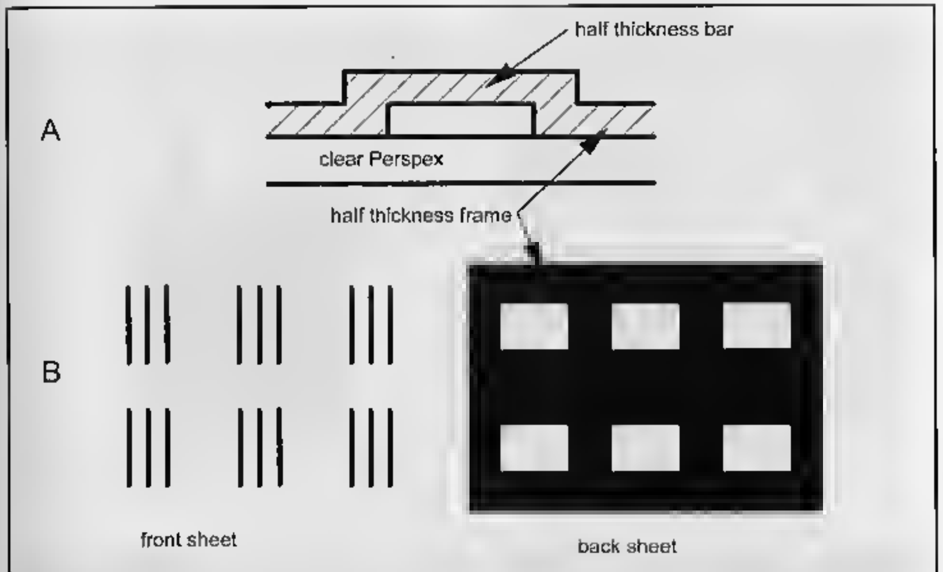


Fig.5.23A *A cross section showing half thickness bars proud of half thickness frame.*

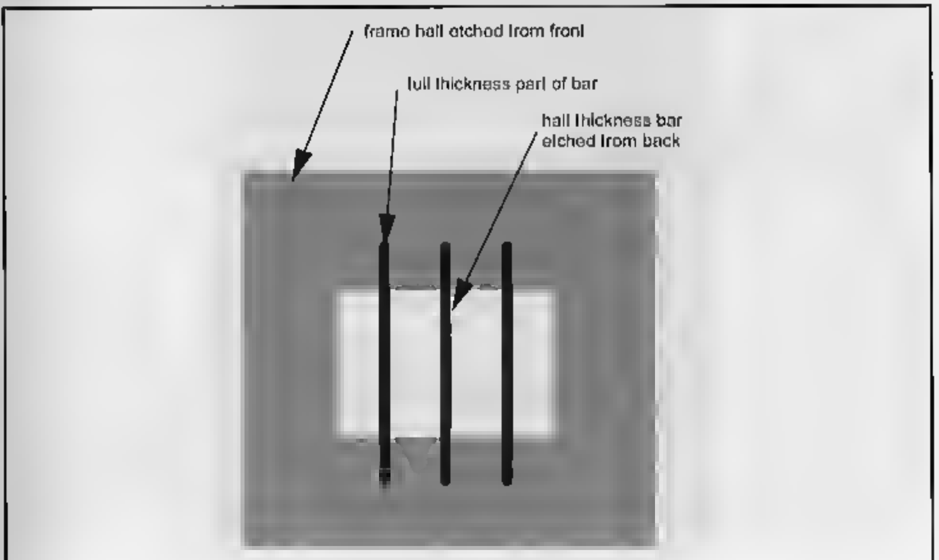


Fig.5.23B *CAD etching drawings for* ***Fig.5.23A.***

presents no problems however the artwork is drawn and transmitted, but the effect is not what is required as the bars should be above the frame surface. **Fig.5.21A** shows the cross section achieved by this technique and **Fig.5.21B** shows the etching drawings for a similar skylight frame and bars.

Method 4 What you can now do is dependent on how you draw and transmit the information. Using the drawing board, the frame can be half-etched (drawn in red) and the bars drawn in black giving you full thickness. See **Fig.5.22A** for the cross section and **Fig.5.22B** for the etching drawing. Again this is not quite what you want.

Method 5 Using CAD, the frame is drawn

Fig.5.25 *Drawings for a hatch cover and hinges.*

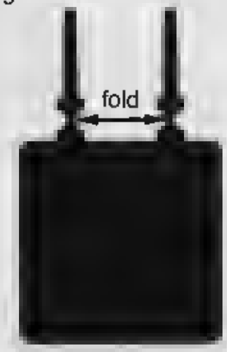
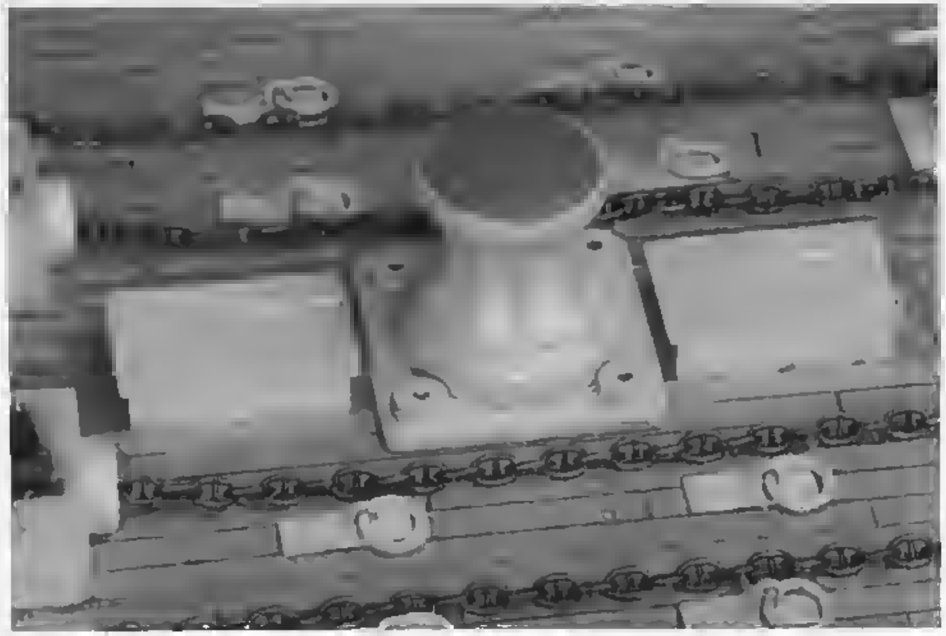


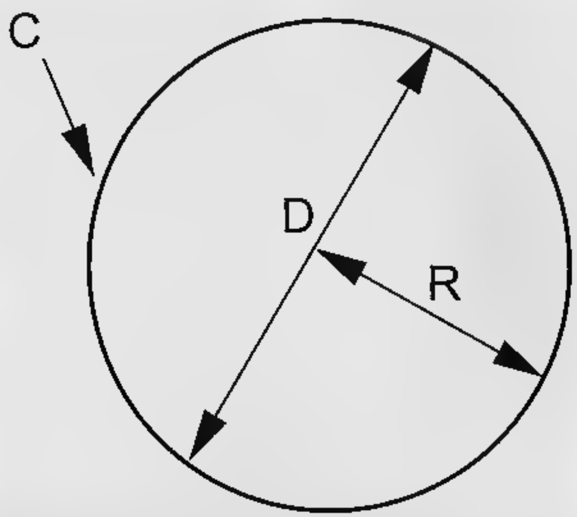
Fig.5.26 *The finished hatch covers fitted on HMS Camperdown .*



in black on the back acetate and the bars, again in black, on the front copy. Thus you will produce a half-etched bar lying on the half thickness frame which is what is required. See **Fig.5.23A** for the cross-section. **Fig.5.23B** shows the etching drawing front and back as drawn using CAD. It is possible to achieve the same effect using a drawing board but it is very much more difficult this way. See **Fig.5.24**.

One point to remember is that if a unit can be etched as one part instead of several bits it both saves assembly time and probably ends up a more accurate job to boot! **Fig.5.25** shows the drawings for a hatch cover, which has hinges attached. **Fig.5.26** shows the completed covers with the hinges bent back

Fig.6.1 Circle.



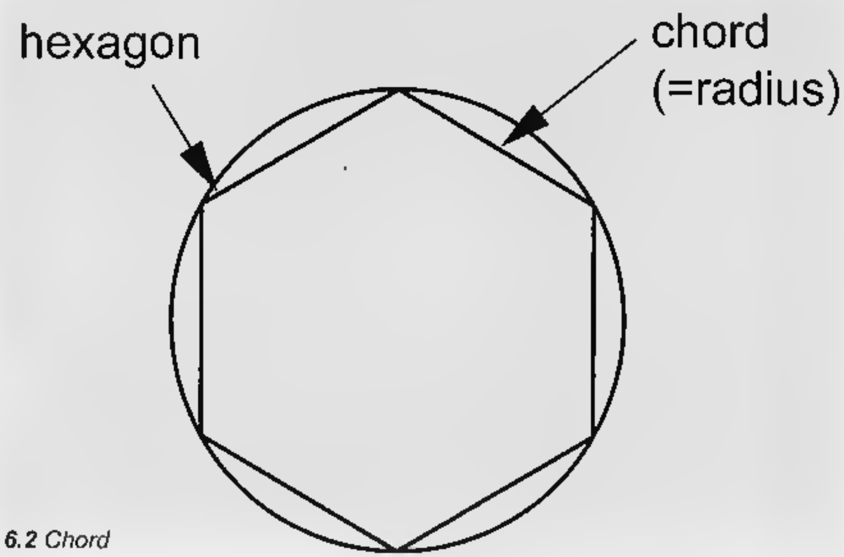


Fig. 6.2 Chord

CHAPTER 6

THE MATHS BIT

The kind of number crunching we need lo produce correct artwork in this game is simple and quite fulfilling. For those of us whose job does not need any maths, and dare we say it, some who do, this work can be quite salisfying.

Malhs usually intrudes when we attempl to develop 3D components (3D components when finally bent up) inlo flat 2D shapes.

This chapter therefore allempts to show, by reminding you of lhe "lools" available, how to solve any problems likely to be encounlered. You almost cerlainly learnt these at school but they have long since been shunted Into the inner recesses of your brain. Prepare lo dig them out and have fun!

Properties of a circle

The diameter goes into the length of lhe circumference approximately 3.142 (22/7) times. The exact figure is indeterminate. This figure is known as π (pi). Nole il is a ratio and has no units. You cannot have π mm for instance! Even you will remember that the radius (R) is twice the diameter (D). **Fig.6.1**.

So we can set these down as formulae:

D = 2R   D x π = C

where **D** = diameler, **R** = radius, **C** = circumference

In case you need it lhe area of a circle is:

π R² or π D²/4

Why this is so need nol worry us at this stage. The real reason is - I cannot recall why eilher!

The sign ² means the number is squared I.e. multiplied by itself hence 3² = 3x3 = 9.

The olher useful attribule of a circle is that lhe radius used as a chord goes into the circumference six times. You can slep it off with a pair of compasses. It makes setting out hexagons (6 sided figures) a piece of cake. See **Fig.6.2**

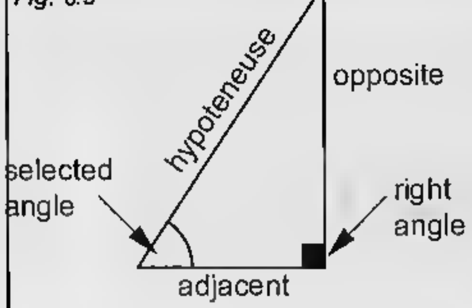
Properties of Triangles

These crop up regularly in the preparatlon of artwork so its deslrable to know your way around them. In general the right-angled triangle is the animal you encounter most. Let's label lhe parts (**Fig.6.3**):

OPPOSITE (because it is "opposlte" to the angle selected)

ADJACENT (because it is "adjacenl" to the angle selected)

Fig. 6.3



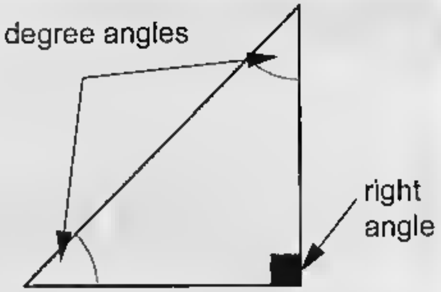


Fig. 6.4

Note if the other angle (the one at the top of the triangle) was the selected angle then OPPOSITE and ADJACENT would be reversed.

HYPOTENEUSE is the side opposite the right angle.

Let's see where this takes us when manipulating lengths of sides and angles.

Firstly the mighty Pythagoras told us that the square on the hypotenuse is equal to the sum of the squares on the other two sides.

Or, if you like, on the above triangle:

$\mathbf{H^2 = O^2 + A^2}$

(It is usually expressed as:

$a^2 = b^2 + c^2$

but that is the mathematicians way of blinding you with their expertise!)

This is always the problem with "experts". They jargonise the simple to kid you they are the experts. My experience has been to avoid, like the plague, being taught mathematics by a mathematician – find yourself a practical engineer because they know how to convert bull to useful practical knowledge.

For instance, Pythagoras can be very useful for laying out right-angled triangles. A triangle with sides of 3, 4, 5 units (or any multiple of these numbers) is a right-angled triangle.

Check: $5^2 = 3^2 + 4^2$ that is: $25 = 9 + 16$

Or: $15^2 = 9^2 + 12^2$ that is: $225 = 81 + 144$

The other thing to remember is that the internal angles of any triangle always add up to 180°. Take, for instance, a 45° setsquare: **Fig.6.4** (45°+ 45° + 90° = 180°). This also applies to non right-angled triangles.

Secondly we now come to the trigonometrical (trig) ratios which enable us to calculate unknown angles and lengths of sides. For some unknown reason (I have spent the last 65yrs trying to find out why, it's those mathematicians again) they are known as sine, cosine and tangent or simply sin, cos and tan. There is no mystification here as they are the ratios of lengths of sides for a given selected angle. The three ratios are:

sin A = OPP/HYP
cos A = ADJ/HYP
tan A = OPP/ADJ

The easiest way to work out trig ratios is to use a scientific calculator, which has the three trig ratios together with square roots. ($\sqrt{\ }$)

Take a simple 30° right-angle triangle

Fig. 6.5

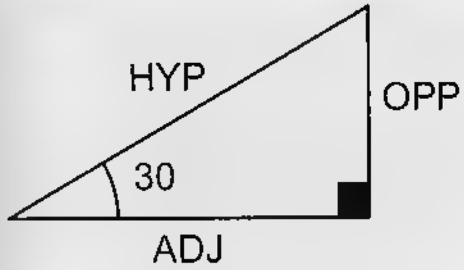
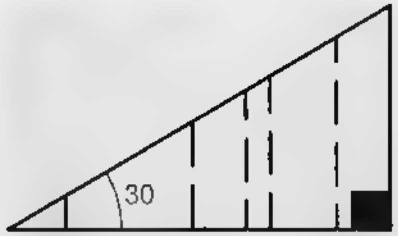


Fig. 6.6



as in **Fig.6.5**:

Now sin A (in this case 30°) gives the ratio of the lengths of the OPP and HYP sides. Thus **sin A = OPP/HYP**. Now if A = 30° ; sin 30° = 0.5, which is simply the ratio between the lengths of the OPP and HYP i.e. the OPP is half the length of the HYP. This ratio is correct for any size triangle (see **Fig.6.6**). The value of sin 30° can be found using mathematical tables or a calculator with trigonometric values (by punching 30 and $\sin^{-1}$)

In practice, this means that if the lengths of either the HYP or ADJ are known for a 30° triangle the length of the other side can be found. Conversely, if both lengths are known the angle between them can be found. It's all VERY simple.

Take a further example (**Fig.6.7**) Using trig ratios find the length of the side marked x. Firstly one has to identify the sides of the triangle (**Fig.6.8**).

The **angle A = 29° OPP = 15** and **x is the ADJ**. To find which trig ratio to use you need to find the ratio which encompasses OPP and ADJ.

From observation the only one is:

tanA = OPP/ADJ

Substituting the known values we get:

tan 29° = 15/x.

There is only one unknown in the equation and therefore it can be solved. A bit of

Fig. 6.7

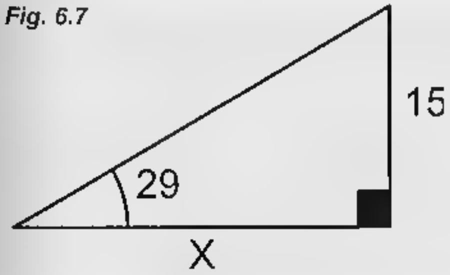
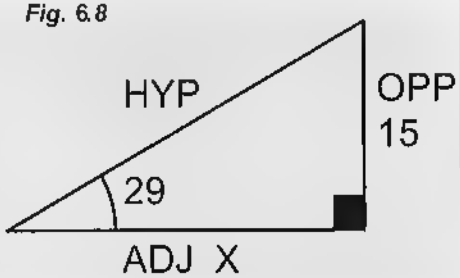


Fig. 6.8



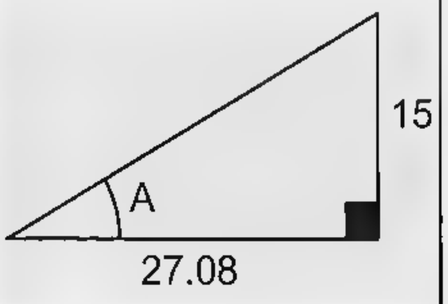


Fig. 6.9

algebra is required to rearrange the formula:
Multiply both sides by **x**, we get:
xtan 29° = 15x/x
and dividing both sides by tan 29°, we get:
xtan29°/ tan29°= 15x/xtan29°
cancelling terms we finally get:
x = 15/ tan 29° = 15/ 0.5543 = 27.08
Always check the answer is roughly correct and it should not be 270.8 or 2.708!!
Taking the above example again but, in this case, we now know the length of the OPP and ADJ but not the angle A; see **Fig.6.9.** We again used the tan ratio so we have:
tan A = OPP/ADJ = 15/27.08.
To solve this divide 15 by 27.08 on your calculator to get **0.5539143.** With this figure on the calculator press the INV button and then the tan button to get **28.982697°.** The reason we do not quite get 29° is that we rounded up the 27.08 figure.
If the length of the HYP is required you can either use Pythagoras:

HYP =√(27.08 + 15)

or use another trig ratio, say sine or cos.

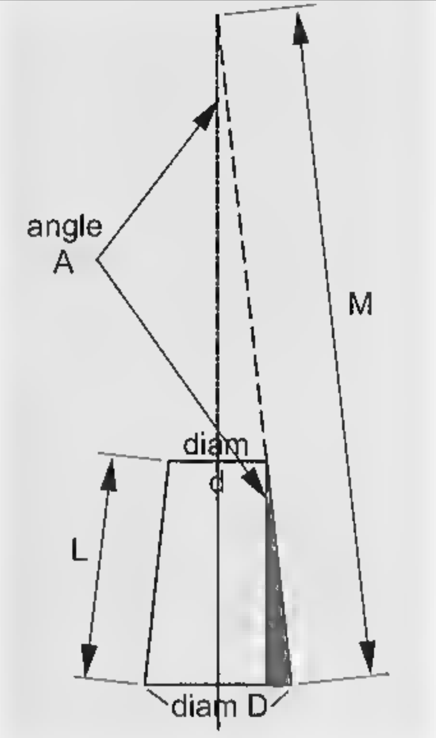


Fig. 6.10

Frustum of a cone

One of the problems you may face when producing artwork is the development of a frustum of a cone. Gun mounts are often this shape. Perhaps the best option is to turn them on a lathe but if they have lightening holes a development may be the only way as these can be incorporated in the development.

Assume this is what is required (**Fig.6.10**). Firstly you need to complete the cone to obtain the maximum radius of the development (M). To find this use trig to calculate the angle A (**Fig.6.11** – the shaded area of **Fig.6.10**)

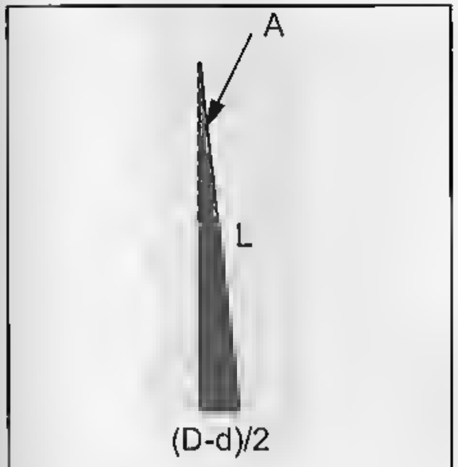


Fig. 6.11

Equation No1:
sin A = (D – d)/2 ÷ L = (D – d)/2L
With the angle A known the slant height of the complete cone M can be found from the triangle shown. See **Fig.6.12.**
Equation No2:
sinA = (D/2)/M;
sinA = D/2M;
2M = D/sinA;
M = D/2sinA
A and D/2 are known, therefore M can be calculated. We can now partially draw the developed shape (**Fig.6.13**) but we do not know the angle S:
The complete circumference of the circle radius **M** is **2πM**. What we need to know is the angle **S**, which requires finding what proportion of the total circumference is occupied by the arc AB. But AB is the length of the circumference of the base of the cone pD.
So the **angle S = πD/2πM x 360°**

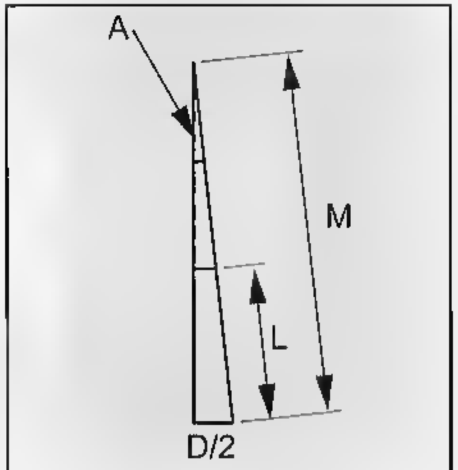


Fig. 6.12

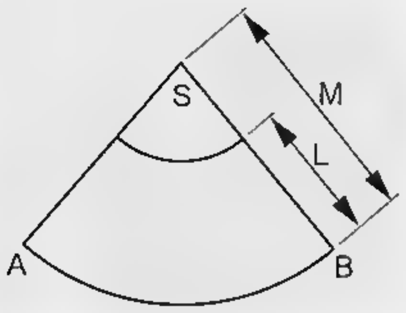
Cancelling terms this reduces to:
S = D x 180°/M
Equation No3: S° = 180D/M
With S known, the development can be drawn out not forgetting any tag if required for assembly purposes. Your calculations can be done by substituting actual figures in Equation Nos 1, 2 and 3.

True length of a line

A neat little problem which shows up the necessity of knowing what is and what is not a true length is shown. **Fig.6.14** shows three views of a deck fitment drawn in first angle projection. The problem is to develop this shape for etching. The difficulty lies in finding the angles in the corners; the rest is straightforward. See **Fig.6.15.**

The shape of the top rectangle i.e. the folding lines in "blue" is taken from the plan and both dimensions are "true". The width of the flanges is dimension A which is

Fig. 6.13



shown as a true length only in the top two views. So "A" becomes the width of the flanges on the development. Dimension BC is true as we have said and so is DE. With these measured the correct angle for the ends of the flange is found by joining DB and CE. The end flanges are similarly constructed.

It should be noted that the flanges are shown foreshortened on the plan. These dimensions are not "true".

Fig.6.16 is the brass etching of a coaming made for RN "Duilio", which was developed as above. **Fig.6.17** is the etching folded up.

Fig. 6.14

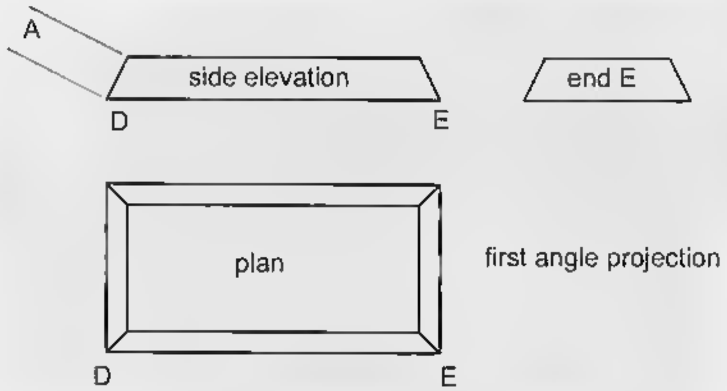
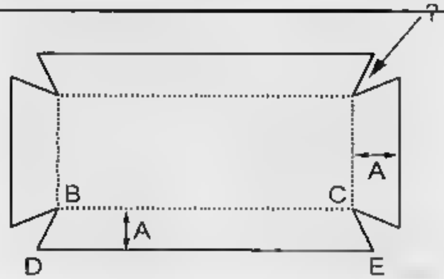


Fig. 6.15



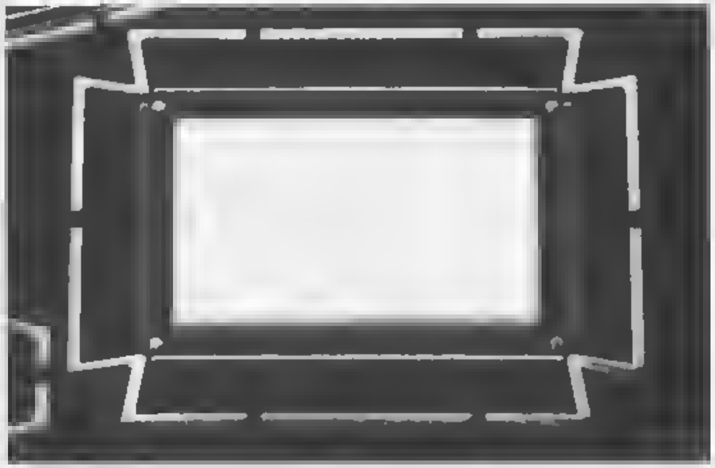


***Fig.6.16** Brass etching of a coaming.*

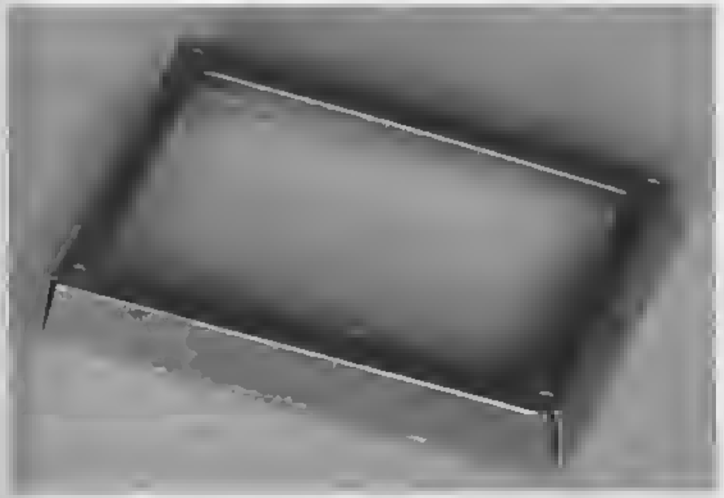
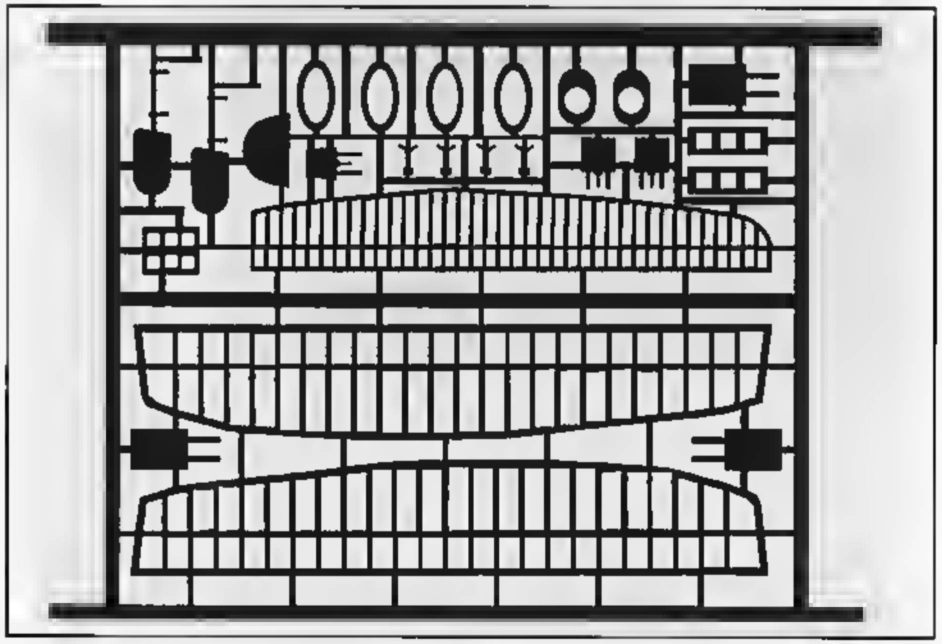


***Fig.6.17** Coaming folded up ready for painting.*

Fig.7.1 The basic frame limiting the size of available space with a built in length datum which must be marked.

Fig.7.2 Careful use of space. The ribs are mirrored to enable other components to be slotted in.



CHAPTER 7

SHEET LAYOUT

It is probably a good idea to lay down a series of criteria that we have learned by experience and need to be followed. These have been arrived at in consultation with our etcher and may need altering when working with your particular firm, which may have different specifications. The sheet layout is most important when considering industrial etching as it is large and costly.

Some of the following points may have been referred to already where it was thought to be essential but we will elaborate here.

Border

We have already discussed the importance of knowing your etcher's camera capacity and maximum etched sheet size. When you have this information create a border to include a length datum. **Fig.7.1.**

Arranging the components on the sheet

Ignoring the preparation charges the cost of each etching sheet is the same (size being the same) whatever its contents so use the area available fully. If you have spare area on a sheet think of some universal items that you may want in the future and use this space for them e.g. strips of varying width, grids, brackets, wheels. The bigger area you have the more efficiently you can use it by careful placing of the parts on that area, **Fig.7.2.** At this stage multiples of any items must be laid out taking into account any mirrored copies. Make sure you have the correct number and they are the right size. **Fig.7.3** is an etching sheet with a crow's nest floor, which we drew half size by mistake. Probably one of us was working in diameters and the other in radii. Too many cooks spoil the broth!

It is inadvisable to have flimsy detail attached to large heavy pieces as, although on paper this looks perfectly satisfactory, in use it is better to separate these two kinds of pieces with a rigid matrix.

Matrix

As the components are arranged on the sheet you will need to provide a framework of full thickness metal to attach the components to. Without this the whole

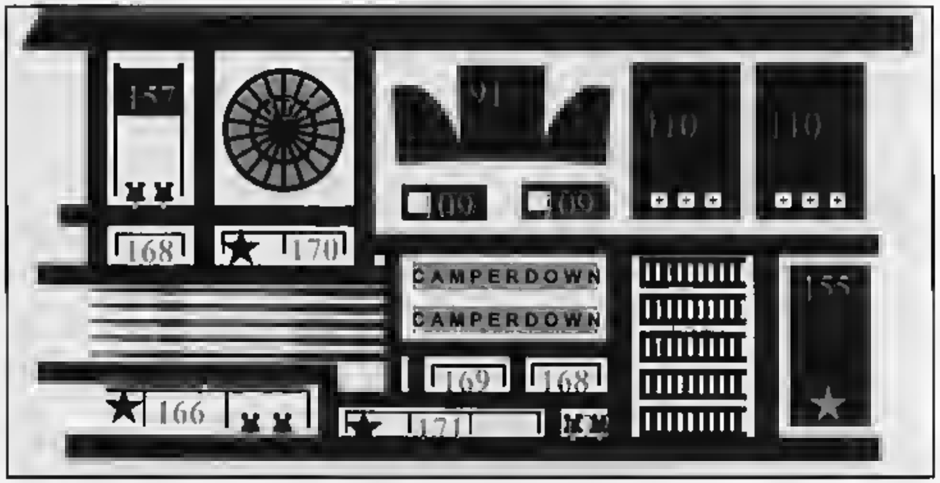


Fig.7.3 The circular object is the deck of the crow's nest accidentally drawn half the correct size. We did not notice until we came to fit it.

sheet will be too flimsy to handle and parts will distort. ***Fig.7.4.***

Component identification

It cannot be over-stressed how important it is to number and identify the etched components. On first thoughts it might seem that parts should be easily identifiable. Experience has shown this is not so, particularly after a lapse of some time. It may take up to three months to produce an etching sheet drawing. This is because of the time taken to research, design and develop the components before committing them to the drawing. The etching time may be a month and, even after that, considerable time may elapse before you use a particular component. By that time, without assembly drawing, number and identification, you will NOT know what all the parts are for.

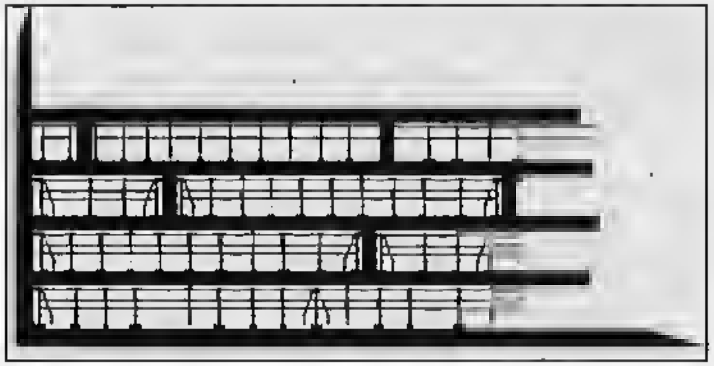
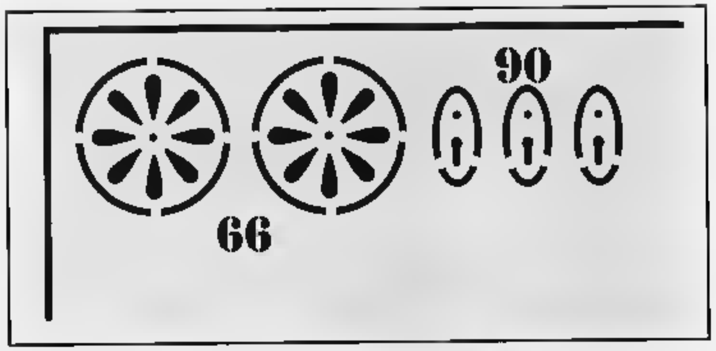


Fig.7.4 *Guard-rail etchings protected by individual frames. This is part of a sheet 18in x 12in almost solely filled with guard-rails.*

Fig.7.5 *A positive drawing with stencil numbers.*



As has been explained the simplest way is to actually put the numbers on the artwork so they appear on the etched sheet. This is synonymous with the way parts in plastic kits are presented. However, space is at a premium with etching, as you pay by area and there may not be enough space. In that case other methods of numbering must be found.

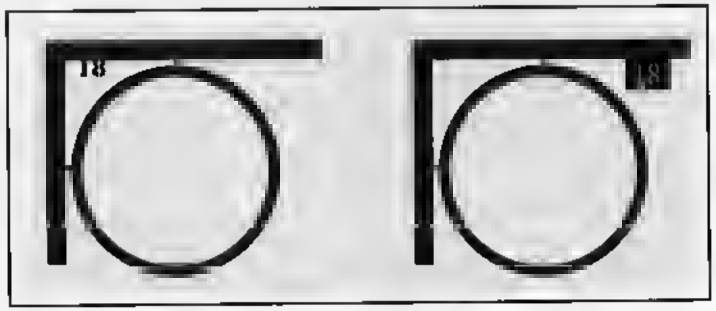
Fig.7.5 and **Fig.7.6** show part numbers on positive and negative sheets produced on the drawing board.

If a rough drawing on tracing paper/film was produced as the initial draught this can be numbered and kept. A list of parts with names and numbers needs also to be retained.

Putting numbers on etching drawings can be difficult as "closed" numbers such as 0, 6, 8, etc. will block out. Any such numbers require to be drawn like stencilled images with breaks in their outlines to retain their centres. Drawings in positive mode can have the numbers half-etched. For drawings in negative mode suitable tabs for the half etched numbers will need to be arranged. Your own ingenuity may dream up other methods of identification.

When using a computer the numbers and any other details can be put on the sheet, this can be printed together with the parts list and kept for future reference. The text can then be removed before the front and back sheets are made. **Fig.7.7** shows a CAD number sheet and the following is the parts list:

Fig.7.6 *Negative drawings with stencil number (left) and tagged, half etched number (right).*



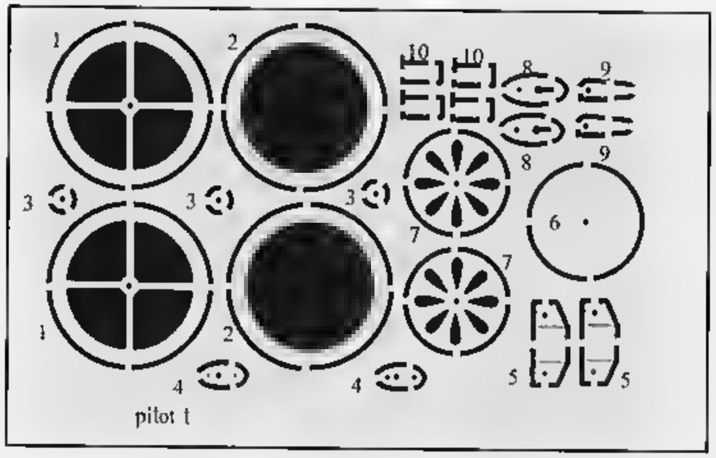


Fig.7.7 A CAD drawing showing the part numbers on the printed sheet to be kept for future reference. See parts list in the text.

Pilot sheet 1

1. hand wheel.
2. hand wheel rim reinforcement.
3. hand wheel hub reinforcement.
4. door handle plate (deckhouse).
5. hinges for small locker.
6. back plate for door ventilator (7).
7. door ventilator.
8. key hole plate (bridge door).
9. catch/handle for small locker (aft).
10. hinge plate for large locker (midships).

Assembly drawing

Fig.7.8 shows the assembly drawing of an accommodation ladder. Its function is to show where all the parts go on this complicated structure. At the designing stage everyone knows where the parts go but come assembly time no one knows. Many months may separate those two dates and a drawing of this type saves a good deal of teeth gnashing believe me!

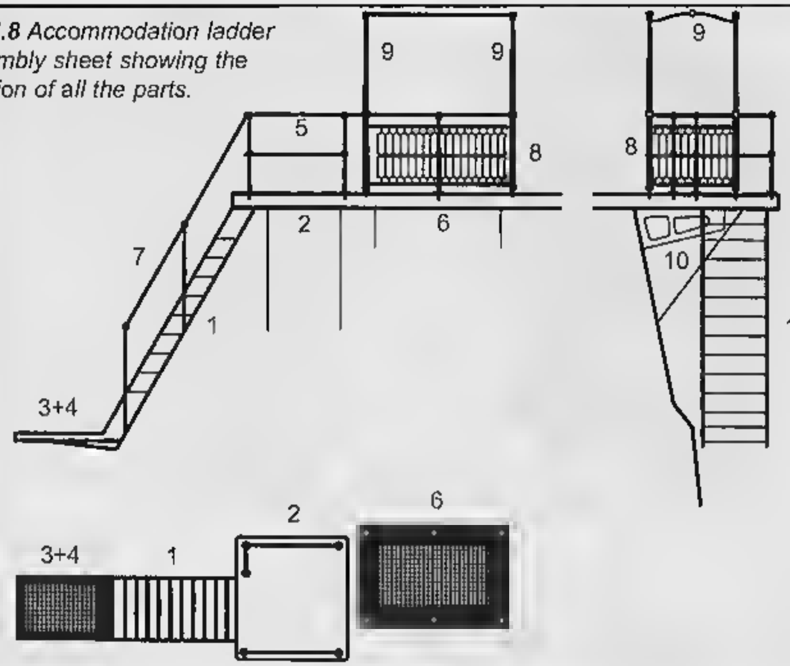
Links to the matrix

As has been explained tags are required to keep the matrix of parts together when using the positive mode of drawing. To make it easier to cut out the parts these tags can be half-etched so you only have to cut through half the sheet thickness. Normally a craft knife or a scalpel is used although in cases where a pair of scissors can be used these are probably best. Unfortunately for parts in the centre of an etched sheet scissors cannot usually be applied. Half etching the connectors from the front also helps the blade find the edge of the component when separating them from the matrix. The tags are put on the back sheet only, on computer drawings as they will then lie flat on the cutting board and the locating ridge will be on top **Fig.7.9.**

Etched parts in stainless steel are very difficult to cut out anyway and half-etching is almost a must.

Originally these connectors were just parallel lines joining the component to the matrix. Very easy to do but this can result in a flimsy matrix which is hard to handle. It may even result in some of the components falling out of the matrix and being lost. Triangular connectors with the point at the

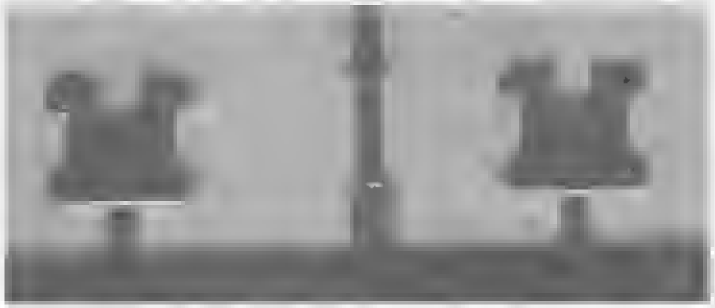
Fig.7.8 Accommodation ladder assembly sheet showing the position of all the parts.



component/connector junction and the broader base giving much more support at the matrix end were found to be preferable. **Fig.7.10.**

Forethought is necessary throughout the whole process and it is particularly important when deciding where to place the tags. Two considerations need to be taken into account. After cutting out the component, the vestigial tags will need to be cleaned up before it is used so placing them where this operation is relatively easy is best. Avoid putting them in awkward corners and on concave edges. The second

Fig.7.9 The different thicknesses of the components (full thickness) and the connectors (half thickness). This provides a locating edge when cutting out.



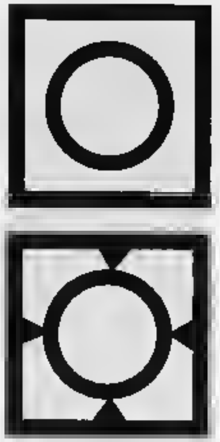


Fig.7.10 *Drawing with triangular half etched connectors giving greater support to the component. Front sheet (above) and back sheet (below).*

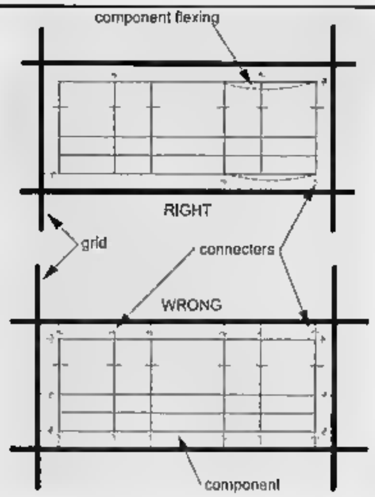


Fig.7.11 *The right and wrong way of positioning connectors on delicate etchings.*

consideration is distortion. Forcing a cutting edge into the matrix usually results in the component distorting, sometimes permanently. Therefore do not put tags opposite to each other. This will allow the component to bend but should not inflict permanent distortion. The same considerations apply to the connecting lines

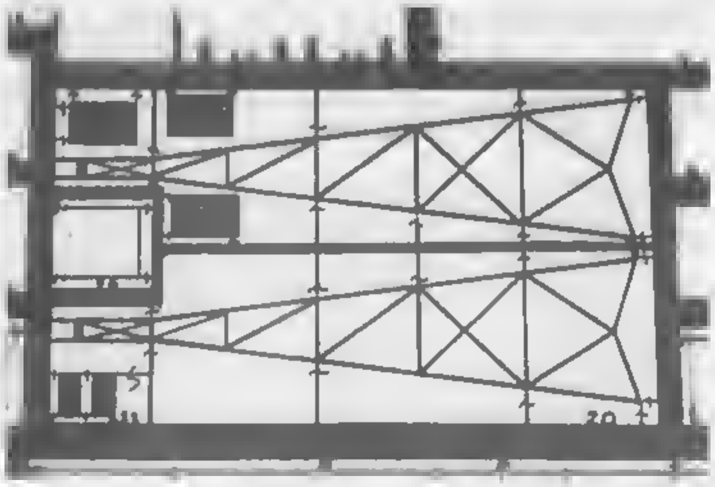


Fig.7.12 *Marking the connectors to distinguish them from the components.*

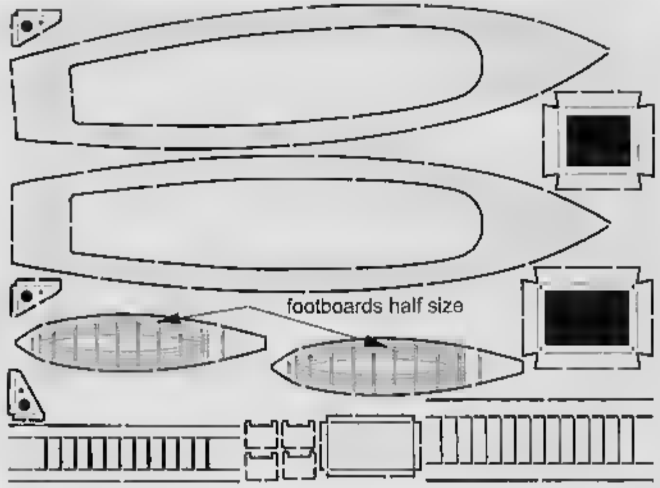


Fig.7.13 *An example of parts, in this case footboards, being drawn half size by mistake. It is obvious they do not match the decks above.*

used in the negative mode artwork. An example of right and wrong design is shown in **Fig.7.11**.

When drawing components in positive mode the black cutting-out lines need to be broken. This can be done on the drawing board by erasing parts of the ink line by scraping it away with a scalpel blade.

When using the drawing board and full thickness parallel connectors it is also a good idea to show which are the connecting lines and not part of the component by marking them. One way is to cross them with a short line in the same way as the continentals cross the tail of their sevens. This practice may not seem essential when you make the drawing. It looks obvious which is component and which is connecting line but, believe me, in six months time it will not be **Fig.7.12**.

You then sit and wait. You may find out some of your clangers immediately on receipt of the etchings. It is very easy to forget to always draw your components to your selected scale and you find that the odd component has been drawn full size and not twice full size as have the rest **Fig.7.13**. Another problem is a hole where the component was not "nicked" (positive mode) or connecting lines have been missed out (negative mode) and it has dropped out of the matrix. These mistakes usually cause strong language but it happens to most of us!

Guides to line up home sheets

If you are etching at home and using a front and back sheet you will need guides to help you line up the two transparencies either side of the brass sheet. You can use locating dots and matching holes in the metal sheet or you can rely on the computer printing the two (front and back) drawings on the same place on the acetate sheet.

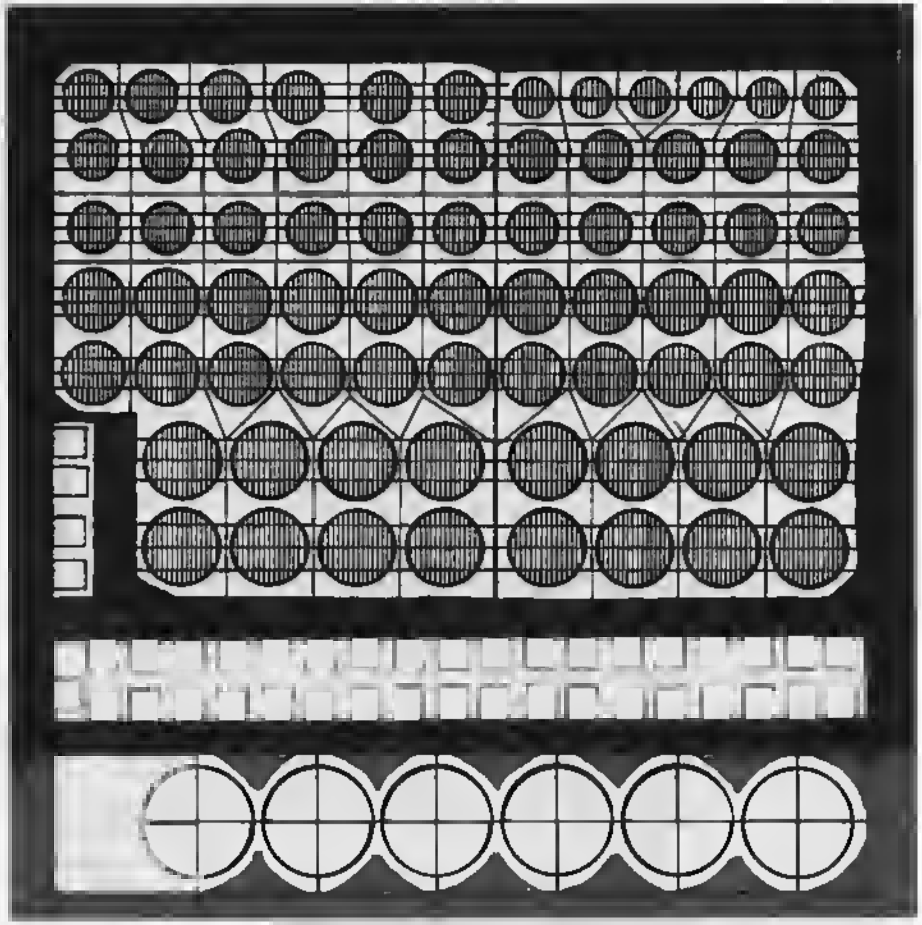


Fig.8.1 *Etching drawing for hull grids, etc for my model of HMS "Queen Elizabeth".*

CHAPTER 8

ETCHING AT HOME

As we said at the start, simple etching can be carried out at home although a better outcome is likely if the actual processing is left to commercial firms. The sea intake and outlet grids on the model of "Queen Elizabeth" were etched at home. **Fig.8.1.**
The basic requirements are:
The material to be etched (usually brass foil)
Etchant – ferric chloride
A source of UV (ultra violet) light
Suitable non-metallic dishes
Photo resist aerosol spray
Alkali developer - sodium hydroxide
Polishing block
Masking material

The use of powerful chemicals obviously has dangers and these must be guarded against. In the case of injury seek medical help.

The usual chemical used for etching is ferric chloride although there are others they are more dangerous. It is poisonous and, in use, gradually becomes copper chloride which is also poisonous – therefore keep away from food and do not ingest any. It will stain skin and should be washed off immediately with soap and warm water. It will also stain clothes.

Ferric chloride reacts with many metals – some violently, aluminium for instance, producing much heat. Care must be exercised in its use to avoid accidental contact with any odd metal objects. If you stain or etch the kitchen sink, the outcome may again be grave! You have been warned – it starts with a new sink and ends with a new kitchen! Do not store ferric chloride in metal containers.

Ferric chloride is usually supplied as a concentrated solution in plastic bottles and will almost certainly need diluting before use. Read the bottle label first, please! It can be obtained in crystal form (ferric chloride rock) which you will have to make up yourself – again read the instructions. It can also be supplied as anhydrous ferric chloride in the form of a black powder (anhydrous means it is without the water of crystallization). This is an unpleasant substance and best left alone.

The developer, sodium hydroxide, is also a toxic chemical and skin and eye contact must be avoided.

The photo etching process

Model etching work is very much akin to PCB's (printed circuit boards), which

Fig.8.2 Polishing the brass sheet with Maplin's polishing block.

comprise an etched pattern of copper fixed to a plastic backing usually Paxolin (phenol formaldehyde impregnated paper) or GRP (glass reinforced plastic). For our work we dispense with the plastic backing which is necessary in PCB's to support the components, etc. Maplin's (Maplin Electronic Supplies Ltd, Rayleigh, Essex) supply materials for PCB's which can also be used for our type of etching work. This description is largely based on material supplied by Maplin as it is relatively easy to obtain in Britain. Follow the instructions on any chemicals you purchase and be sure they are disposed of safely.

Other materials are available to help the process such as a polishing block to clean and polish the base material before starting the process. This block is made of ultrafine non-metallic polishing compound bonded to an elastic base that wears evenly and removes the need for abrasive pastes. A controlled UV light box is also available which enables a controlled amount of UV light to be used. Exposure to sunlight will also do the job but it is variable and very little control is possible.

Preparation of metal sheet

Fig.8.2. The brass sheet must be really clean so that the closest bond between it and the photoresist exists. We have found the use of an abrasive block followed by degreasing is best. If the bond is poor fine detail may be lost. The professional etchers roll the photoresist film onto the cleaned base for maximum adhesion. Home etchers use a positive photoresist aerosol spray. This is sprayed onto the prepared metal sheet **Fig.8.3.** The spraying must be carried out in subdued light in a dust-free area. Any dust included in the coating will obviously affect the image. Shake the can and hold it at an angle of 30-45 degrees about 20-30cm from the surface. The aim is to get a smooth even coating onto the surface. Leave for 5min in a horizontal position in low light levels until it is touch dry. Then

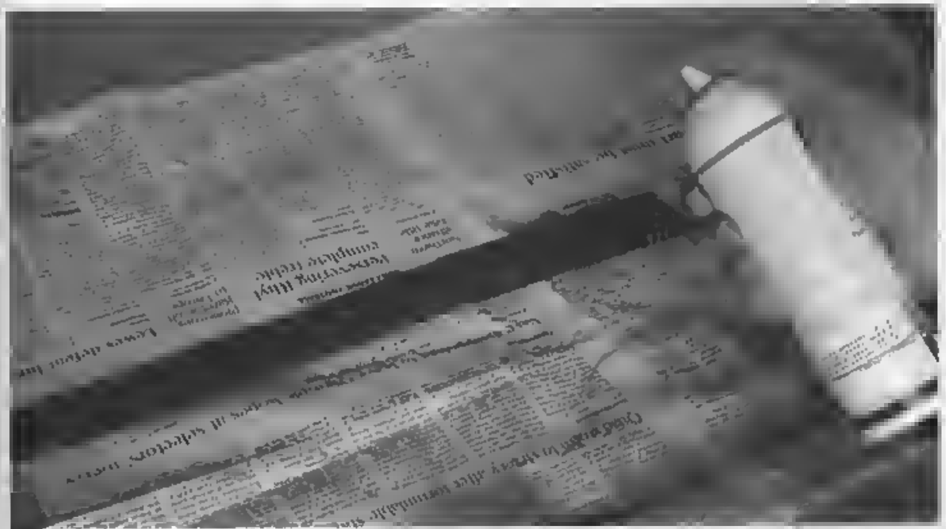


Fig.8.3 Spraying the positive photoresist. Note that the sheet must be horizontal to ensure an even coat.

move it to a dark but well ventilated enclosure and leave to dry for 24hrs. Alternatively it can be heated to 80°C for 15mins but, as the chemical is flammable, no open flames or incandescent elements can be used for this. If single-sided etching is being done the back of the metal sheet must be protected. Paint the surface or cover with sticky backed plastic or adhesive tape so the etchant has no access.

Exposure to UV light

The next step is to expose the photosensitive film to the image of the parts you require. This is done by placing a transparency, with the design imprinted on it, against the prepared surface and exposing the assembly to ultraviolet (UV) light. For the sharpest result the side of the transparency with the image on it should be against the emulsion. **Fig.8.4.**

If you are etching from both sides the two images must be in perfect alignment. One way of doing this is to join the two sheets along one edge (preferably the longest edge) and after checking for alignment accuracy, slide the prepared brass sheet between them and secure the resultant sandwich. **Fig.8.5.**

Any source of UV light can be used, daylight for instance but a controllable source is obviously best. Maplin make a UV light exposure unit, which is pricey but ideal for the job. **Fig.8.6.** The exposure using the box should be in the order of 8-15mins. You can confirm this by using a test strip in the same way as you would for photography, bracketing the expected time to select the best figure. For those not familiar with this technique, it consists of exposing a short length for 5mins with the rest of the strip covered up. The next short length is exposed for a further 5mins and the final length again for a further 5mins.

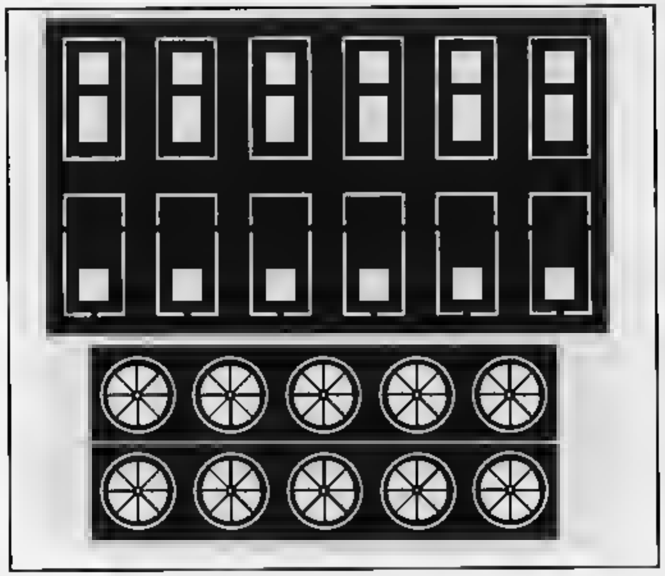


Fig.8.4 Transparencies prepared for etching. The upper two rows (for front and back sheets) are doors with half-etched panels on the bottom of the door. These panels appear only on one side. The lower two identical rows are wheels which could be etched single or double sided.

You then have a photoresist coated strip with the artwork attached where the first part has been exposed for 15mins, the second for 10mins and the third for 5mins. From this the correct exposure time can be judged. We found twelve minutes using a box with two tubes was about right. **Fig.8.7.** Too long an exposure will burn out some detail and too short will give a weak image.

As the box produces UV light care must be taken not to look directly at the lamps.

Development

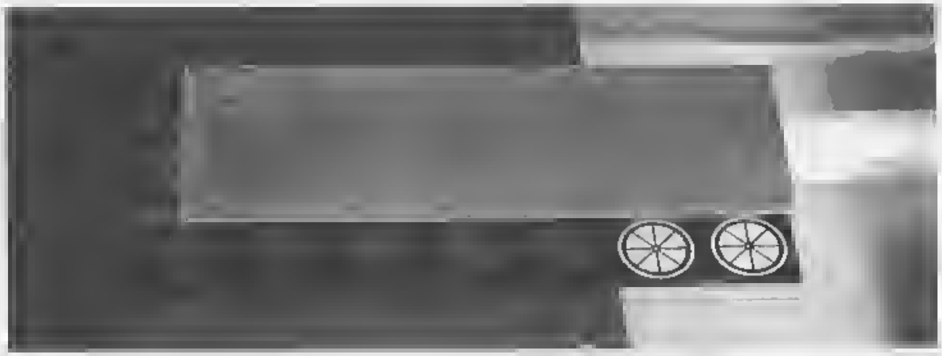
This is done by immersing the metal sheet (minus the transparencies of course) in sodium hydroxide (NaOH) solution (7gms/litre). The developing time should be 1-2mins and you will observe the coating wash away from the areas to be etched leaving the components standing out. Wash off the sheet with clean water but remember the chemical you are using is a powerful alkali and should be treated with respect. Wear latex gloves and eye protection. Any splashes on the skin must be washed off immediately. The resist can be further hardened by heating to 60-70°C for 20mins. This will render the resist more acid proof. **Fig.8.8.**

Etching

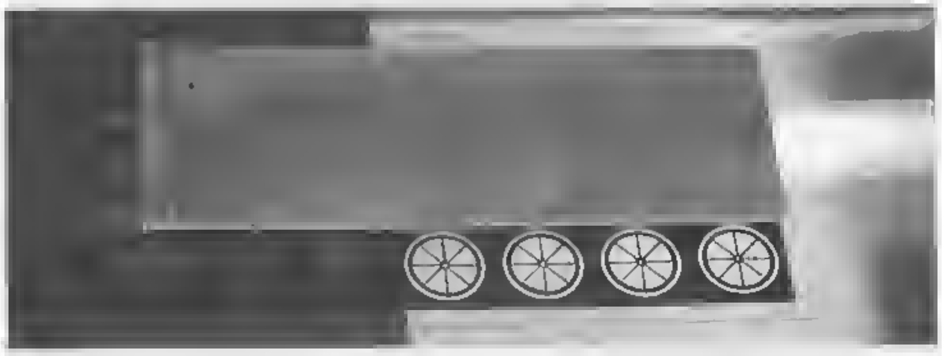
Normally the home etcher will use dish development although the professional machines spray the etchant onto the surfaces, which gives a cleaner and faster result. A bubble tank is also available, at a price, for the serious home etcher. With dish etching the working surface should be underneath and not too close to the bottom. If you suspend the job in a dish use a plastic covered wire to prevent etchant attacking the wire. Suspension upside down is necessary as the chemical reaction produces iron which is precipitated and if

Fig.8.5 The two rows of doors have been lined up with the ink sides facing each other, and taped in place. The prepared brass sheet is then sandwiched between them. The top (window) will etch right through but the lower panel will only etch from one face.

Fig.8.6 The ultra violet light box which will only illuminate one side at a time. Therefore with double-sided etching both sides will require exposure.



The three stages of test strip exposure - **Figs 8.7A, B and C**



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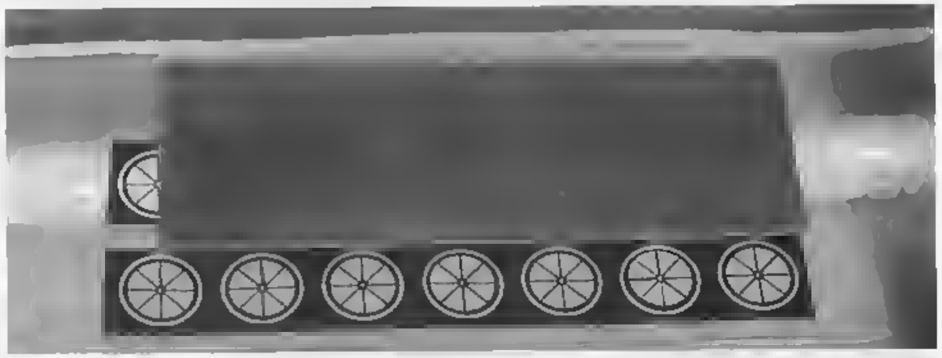


C

Fig.8.8
Development in sodium hydroxide (caustic soda) which exposes the areas to be etched.

Fig.8.9 *Etching underway using ferric chloride. Note the latex glove and the use of plastic tweezers. The etchant dish is in a heated water bath to speed up the process.*

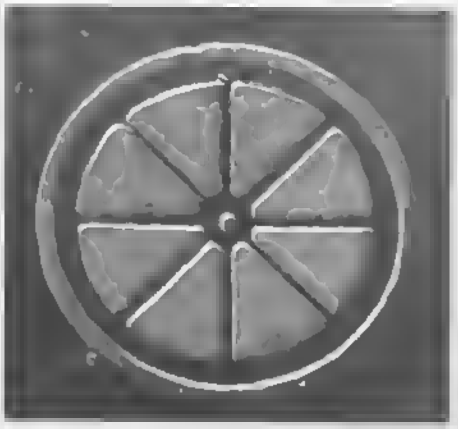


Fig.8.10 Final etched wheel which is supported by the sticky plastic on the reverse side of the sheet. There are no connectors.

this remains on the sheet surface, as it will if the sheet is the right way up, it inhibits the etching process. If it is suspended upside down the iron will fall away. We found continuous agitation speeded up the process.

Fresh ferric chloride ($FeCl_3$ – 500-1000gms/litre) is reddish-yellow brown in colour and turns green as it becomes more contaminated with the copper and zinc chlorides produced with use. When the solution turns green it Indicates that it has reached the end of its working life.

The etching should be done as quickly as possible so that undercutting is kept to a minimum and the resist is subjected to the least stress. Heat (50-60ºC) will speed the reaction and can be provided in the form of a waterbath. **Fig.8.9.**

Remove the sheet from the etchant as soon as it is finished and wash off with clean water and dry. Be careful with the drips as they will deposit a copper coating on steel sinks. It is still corrosive to ferrous (iron) materials.

Fig.8.10. shows the finished etching. The remaining resist can be removed with a solvent also supplied by Maplin or physically with an abrasive.

For very small sheets glass jars can be used to contain the solvents and etchant. The work can then be held in forceps and agitated in the etchant to speed up the process. **Fig.8.11.**

If single-sided etching is being done with a sticky plastic backing (on the non-etched side) the components will remain adhered to the backing and therefore no connectors are required to link them to the matrix. However, if the parts are delicate removal from the adhesive may be difficult owing to the possibility of distortion.

Fig.8.12 shows the slight variations in etching speeds where some items are finished and some show remnants still in place. In this case this was probably due to unevenness in the photoresist film. It can also occur because of slight variations in the brass stock.

With double-sided etching, connectors are necessary otherwise parts will drop out into your etching bath. **Fig.8.13** shows doors produced by double-sided etching. The top panel (the window) is etched right through whereas the lower, decorative panel is only half etched. We have deliberately removed the etched sheet from the bath just before completion to show the last remnants of brass remaining in the holes.

Etching tends to be more vigorous at the outer edges of the sheet and therefore delicate detail is best sited in the centre.

Fig.8.11 For very small etchings a glass of developer and a glass of etchant in a heated water bath.

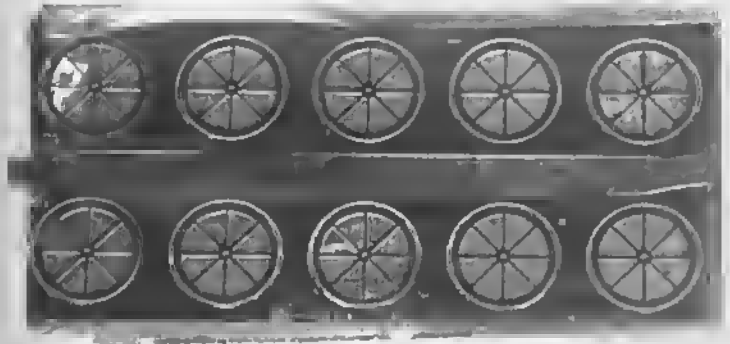


Fig.8.12 Finished etching with ten wheels. The faults in the central lower wheel were caused by the uneven application of the photoresist. This can be seen in Fig.8.8 on the right hand side.

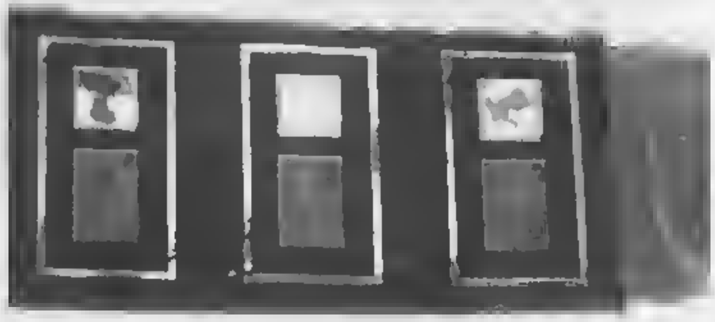


Fig.8.13 Three etched doors which were removed from the etchant slightly early to show the process not quite complete. Note the half-etched lower panels.

CHAPTER 9

INDUSTRIAL ETCHING

As we have said before etching can be done at home as the authors have proved but, for anything more than the simplest job, the actual etching is best left to the professionals. They have the equipment, expertise and experience to produce the best job from your artwork. However, they will not produce perfection from sub-standard artwork but, at least, the quality of artwork is in your own domain. Another reason for leaving it to the professionals is that a certain minimum amount of equipment is required which is likely to be used only infrequently and the space occupied could well be put to better use. We find that workshops gradually become overfull anyway – it's a natural progression and space is always at a premium. Anything that can be left out is best left out. The other problem with intermittent activity is the process has to be re-learnt every time and all the equipment has to be re-assembled.

Fig.9.1 Commercial camera lens and bellows.

In this chapter we describe the etching process as carried out by one firm (Photo Etch Consultants in Walsall). We are assured that the main points are pretty universal. We also point out the superiority of the industrial process compared with the "kitchen sink" method.

Production of acetates (photo tools)

The way the artwork is processed depends on the way it is presented. If hard copy is sent this may need "cleaning up" before being photographed. If red and blue lines are used on the original, to delineate front and back details, colour sensitive film is used to produce the front and back acetates. The camera is also used to reduce the image to the final size. Vacuum tables are used throughout the process to hold both work and film flat and keep them correctly located. **Figs.9.1** and **9.2** show the front and back of a commercial camera.

If the artwork is on floppy disc, CD, etc. then the information will need to be converted to a file the XY plotter can read so that it can produce the acetates. The image size is controlled by datum lines on the artwork. CAD lines and shaded areas will be much denser and more accurate than with hand drawn work.

Whichever way the acetates are prepared they have to be registered accurately together to ensure the images on both sides of the sheet are correctly lined up. This is done using an illuminated, freestanding optical microscope sitting on top of the sheets. With this it is possible to see the two images and position them correctly.

Fig.9.2 Back of commercial camera.

The etching process

1. Cleaning The starting point is the cleaning of the brass (or whatever material is being used) sheet with sodium and potassium hydroxide. This must be done to a very high standard akin to the cleanliness required for electro-plating i.e. "molecularly" clean. This degree of surface preparation is required to ensure that the resist adheres to the surface throughout the subsequent processes. Any lifting or

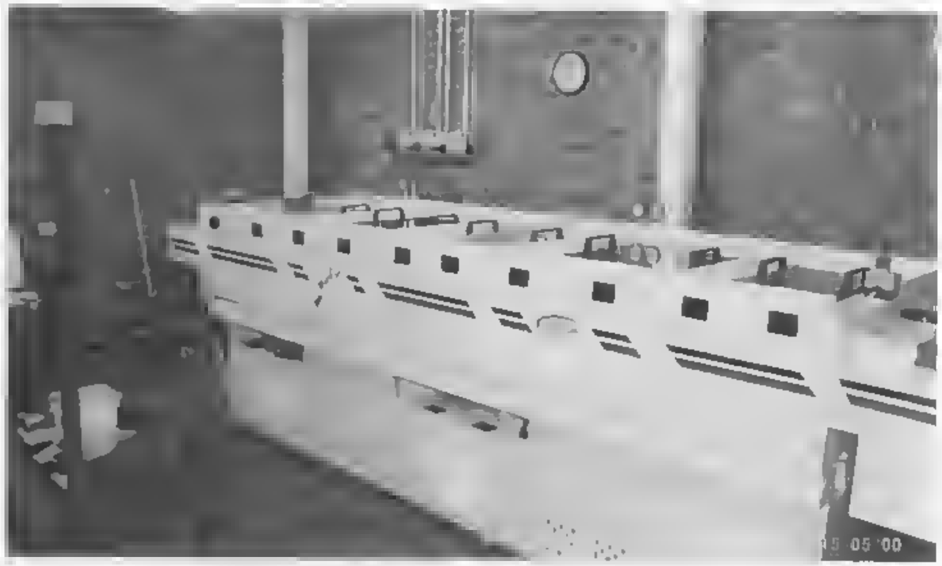


Fig.9.3 Cleaning machine.

breakdown of its protection will degrade the etching and ruin its resolution. See **Fig.9.3.**
2. Laminating with emulsion The resist, a UV light sensitive emulsion, comes as a coating on a transparent plastic sheet. The metal sheet is warmed to 30 - 40°C and laminated on both sides. The plastic sheet protects the surface and is not removed until the image is developed. Because of its UV sensitivity this process, as well as some subsequent operations, is carried out in yellow light to avoid fogging the emulsion.
3. Exposure The prepared metal sheet is then sandwiched between the two acetates and held under a vacuum and the whole assembly exposed to UV light. The UV makes the exposed (transparent) areas soluble in the developer and the covered (black) areas protected from attack by potassium hydroxide. **Fig.9.4** shows a UV light exposure machine. Note: the fluorescent light above the machine is yellow to avoid fogging the photosensitive coating.
4. Development After removal of the protecting plastic sheet and development with potassium hydroxide these soluble areas can be washed off exposing the bare metal.
5. Etching The sheet is then ready for etching. The etching machine (**Fig.9.5**) sprays the warm etchant (ferric chloride) onto both surfaces. By actively spraying the chemical onto the surface etching time is reduced as the unwanted chlorides, produced by the etching process, do not clog up the surface and retard the progress. Fresh etchant is also constantly being applied. The disadvantages of the relatively static emersion technique used at home are thus avoided. Reduced etching times are desirable to avoid undercutting of the resist.

Fig.9.4 UV light exposure machine.

Always, all things being equal, the thinner the sheet the crisper and more accurate the final etched part will be. Overlong etching times will reduce the width of lines etc.
6. Finishing After washing, a final finishing process is applied to both surfaces to maintain its pristine appearance and as a protection from finger marks etc.

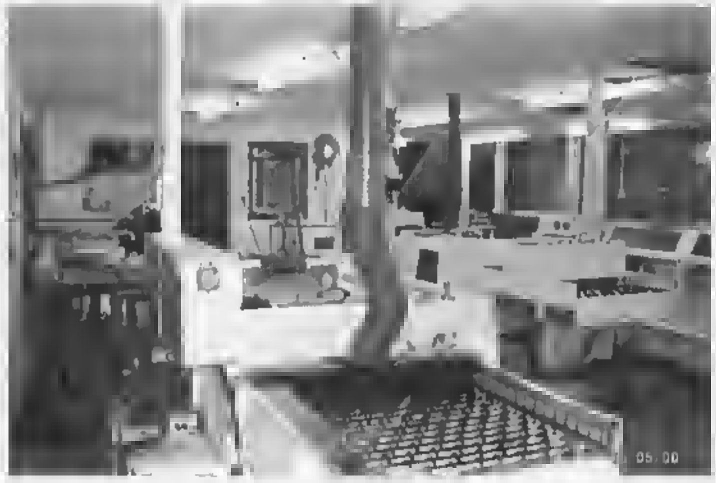


Fig.9.5 Etching machines.

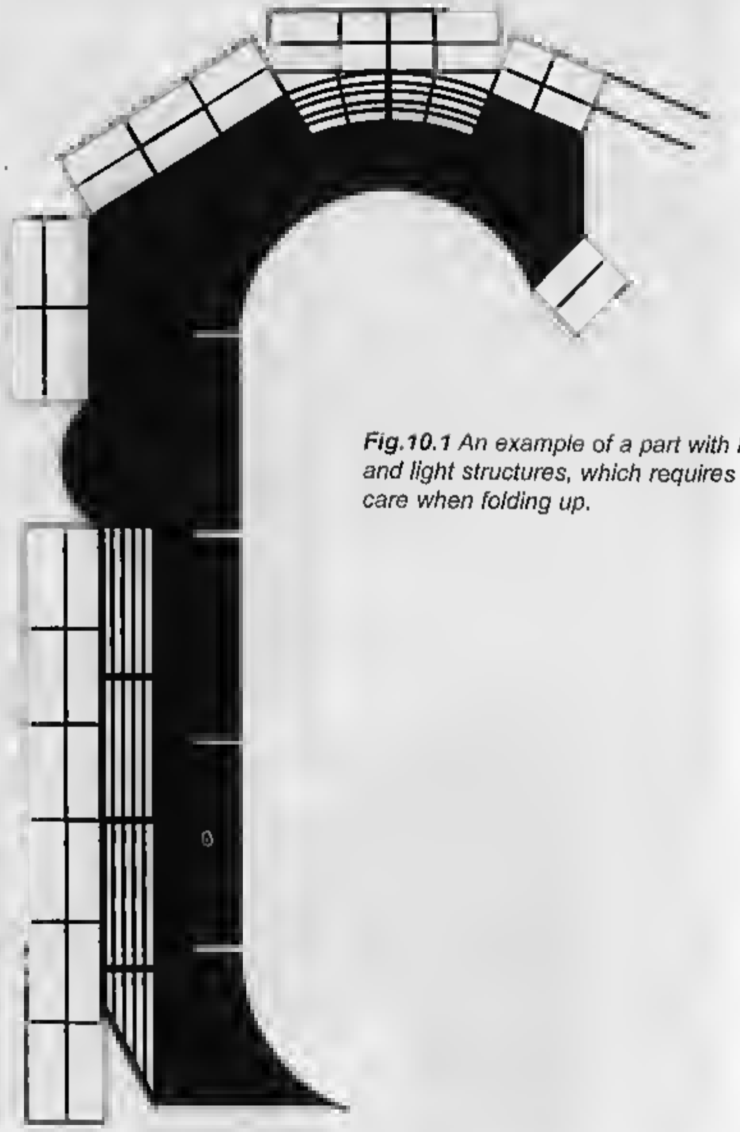


Fig.10.1 An example of a part with heavy and light structures, which requires great care when folding up.

CHAPTER 10

HANDLING AND ASSEMBLING ETCHED PARTS

So all the artwork has been done and the etcher has sent you nice pristine sheets of etching. Of course he may also have sent you the results of clangers in your artwork but nothing is perfect in this life!

Cutting out components

The thinner the sheet the easier it is to separate components from the sheet. Thin brass sheet will surrender to a scalpel; thicker sheet will need a craft or Stanley knife. If the connectors have been half-etched it is usually quite easy to "feel" the edge of the component as it is full thickness. The edge tools will need to be sharpened with a stone every now and then. Try and remove parts without inflicting distortion on to either the part or the rest of the sheet. Unless there is a good reason do not remove parts until they are needed. If you do they will get lost! If not lost then they may become unidentifiable. Never throw away the matrix, as it is surprising how often pieces of this may be useful.

With the parts removed the remnants of the connecting lines or the remains of the tags need to be cleaned up. The methods are up to you. Scissors can be used or files but clean up before attempting to fold up and/or assemble.

Handling

Parts vary enormously – they can be very delicate and require careful handling or quite tough. The worst pieces are those which consist of delicate parts attached to larger areas. **Fig.10.1** shows a funnel gantry for the aircraft carrier "Glorious". Bending the guardrails up was a nightmare but well worth the effort. The secret is to keep control of the part at all times. Allowing it to do its own thing will inevitably lead to folds occurring in the wrong place. If the component has been designed with fold

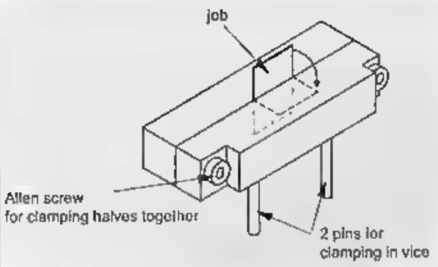


Fig.10.2 A pair of folding bars which facilitate bending etched parts.

lines bending will be much easier. Lack of fold lines means increased force is required and positioning the fold is more difficult. In effect it is always easier to position fold lines on the artwork rather than on the bench.

Folding bars

Fig.10.2 shows a set of folding bars made up to facilitate the bending of components. They are in effect a pair of vice jaws but with the folding edges in better, cleaner condition than your average vice jaws. (There is nothing wrong with just using the vice jaws if they are in first class condition). As can be seen they merely consist of two pieces of mild steel fixed together with socket screws. The tops have been ground level. The protruding bolts underneath are merely for securing in the jaws of a vice. If these were to be made again it would be an advantage to make one end longer, overhanging one of the clamping bolts, so as to have an open ended length. Experience has shown this to be a desirable addition. A Roll-Royce unit would be case-hardened (or through hardened and tempered) and ground. This would wear better.

To use, these folding bars are clamped in a vice and the component inserted down to the folding line and the socket screws tightened. Check that the position is correct before folding. See **Fig.10.3**. The whole length must be folded down at the same time. If you attempt to fold down one end first and then follow this along in the same manner as a ploughshare you will stretch the open edge which cannot then fold down tightly as you have created extra length.

Fig.10.3 Folding the full length in one go using a separate piece of flat steel.

Fig.10.4 Plough folding – not to be recommended.

Fig.10.4. Whether you planish (hammer) down the fold must be left to how tight you need the bend. If you do decide to planish make sure the whole area of the folded piece is covered. **Fig.10.5.** Do not use the hammer without a covering piece between it and the work otherwise you will put in creases and marks. The secret of this method is to make sure the most vulnerable piece of the component is within the jaws if possible. Here it will be protected. You must make sure by controlling it that it bends where you want it and not elsewhere!

Without folding bars the same principle applies – control. Try trapping the component under a steel rule, or the like,

Fig.10.5 Planishing. Note the whole area is covered otherwise the surface gets marked.

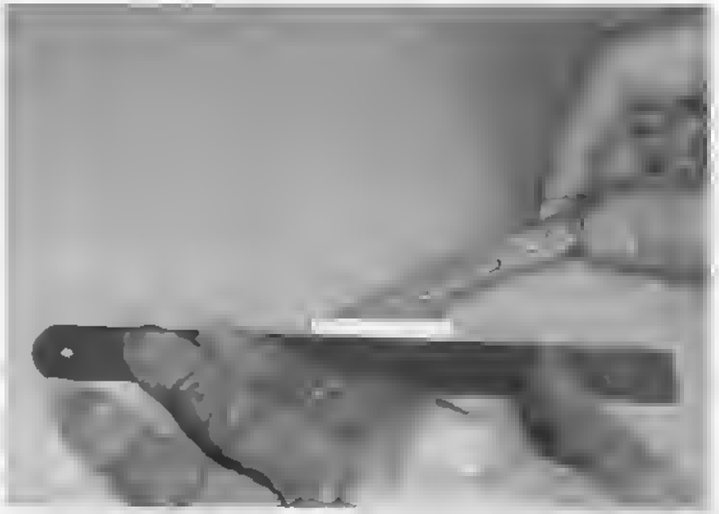


Fig.10.6 Bending using a scalpel and ruler.

and insert a scalpel under the free edge to fold up. **Fig.10.6**.

Folding blocks

Which ever way you adopt the early folds are usually easy; the rest may not be. An example - say you need to turn up the four sides of a rectangle. One side, and possibly one end, is easily catered for using folding bars but the second side and end cannot be fitted into folding bars owing to the initial fold(s). The best way to continue is to make a block to fit into the internal dimensions and this can be used to fold up the other sides in a vice or by opening out the folding bars. The block must be thick enough to clear the already folded edge(s). **Fig.10.7**. Probably the best material for the block is Perspex, or some other plastic or hard wood. Having produced a first class etched part the folding up should always be done with care to avoid spoiling the job. Always check you are folding the correct way. It is easy to fold a component the wrong way when you have been concentrating on getting it into the folding bars in the correct position. Also there may be the question of "handed" components. It is always just too easy to end up with two right hand components instead of a right and a left hand. Navigation light boxes are an example. However, if the fold lines have been correctly drawn i.e. on the right side of the sheet this should lessen the risk. **Fig.10.8** shows a component folded in this way.

Assembly sketches

A certain amount of sketching is needed during the preparation of the artwork to decide how parts are to be assembled and to sort out their design. How assemblies are actually going to be fixed is another problem. So retain sketches of designs.

Take, for instance, a ship's accommodation ladder (see **Fig.7.8**). The assembly for this may well consist of thirty to forty separate parts if it is of the two-

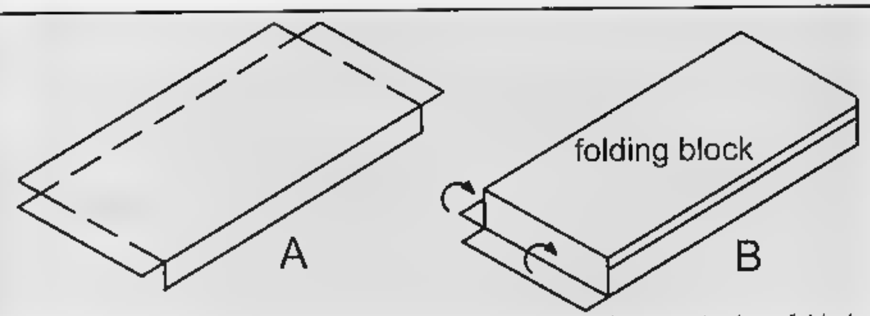


Fig.10.7 A - the component with one edge bent. B – subsequent edges folded up around internally fitted temporary block.

ladder type with a halfway platform. Unless you sketch out and keep a diagram of the assembly, you will end up not knowing where that cunning bracket you designed and drew six months ago was meant to go. To the tyro this may sound like hyperbole but experience shows it to be absolutely true. Even simple assemblies may need to be recorded e.g. which piece overlaps the other? The thought processes gone through when first designing a part are rather like the morning mist, ephemeral, or is it just me getting old?

Assembly of etched parts

To illustrate the handling and assembly of etched parts four examples are discussed, from very simple funnel cages through to a very complicated accommodation ladder.

The first stage is always to identify and cut out the necessary parts from your etched sheets. This is where the

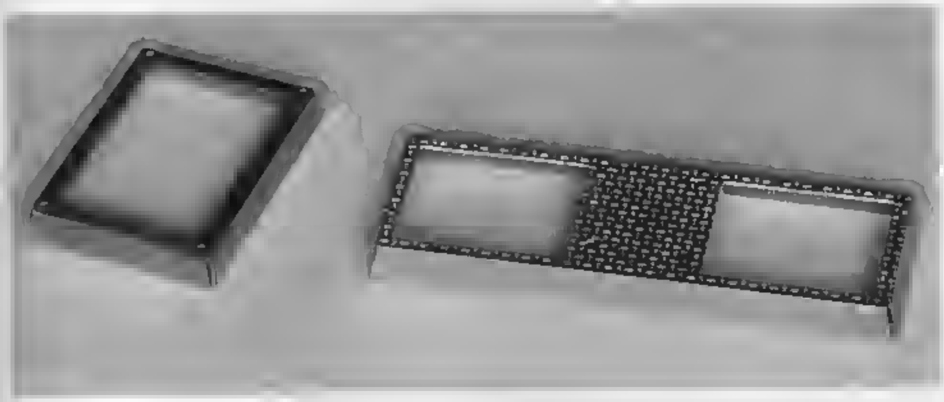


Fig.10.8 A couple of examples of folded up coamings. The folding was helped by half etching on the reverse side and front side etching was used to make the chequer plate.

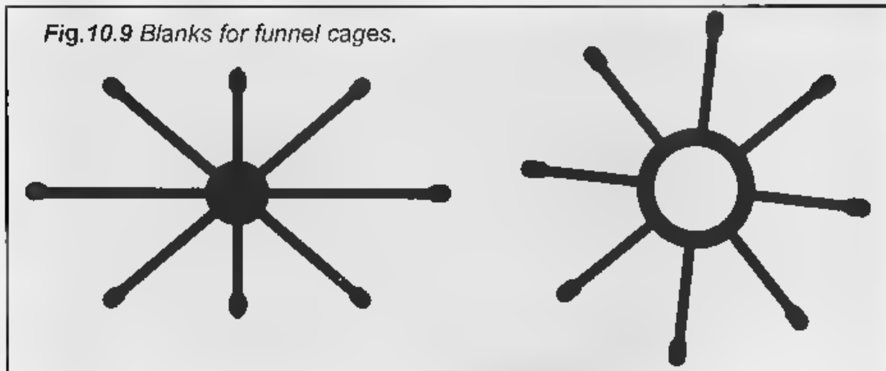


Fig.10.9 Blanks for funnel cages.

component numbering, list of part names, list of code numbers, etc. comes in. If you have followed the instructions given here so far, identification of specific parts should be fairly easy. However, before wielding cutting tools over your pristine etchings, look at the enumerated sketches you will have prepared to see what you actually had in mind when you drew up your etching drawings. This may sound like exaggeration; of course you know which parts you need and where to cut them out. But do you? When assembling the accommodation ladder, twice I had to resort to my spare set of etchings, to cut out new parts because I had cut off a piece, thinking it was merely a connecting tab when it was actually a required part of the component!

Before attempting anything get the feel of the thing and get clear in your mind how (a) it goes together and (b), just as important, how it is assembled to its

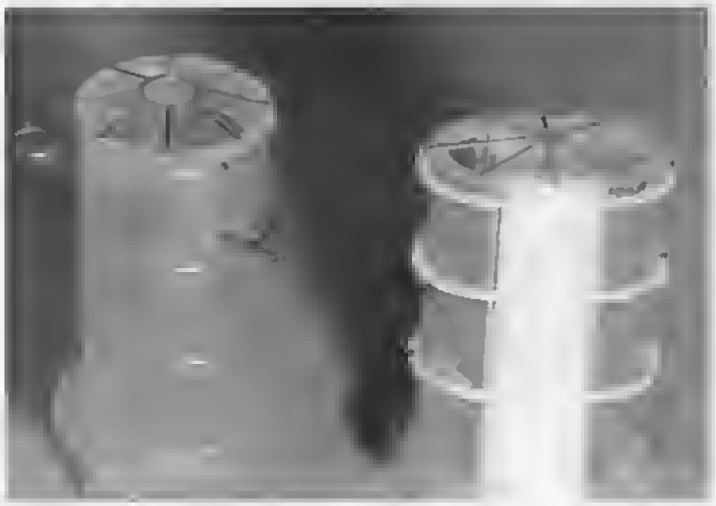


Fig.10.10 The components in Fig .10.9 fitted to Perspex funnels.

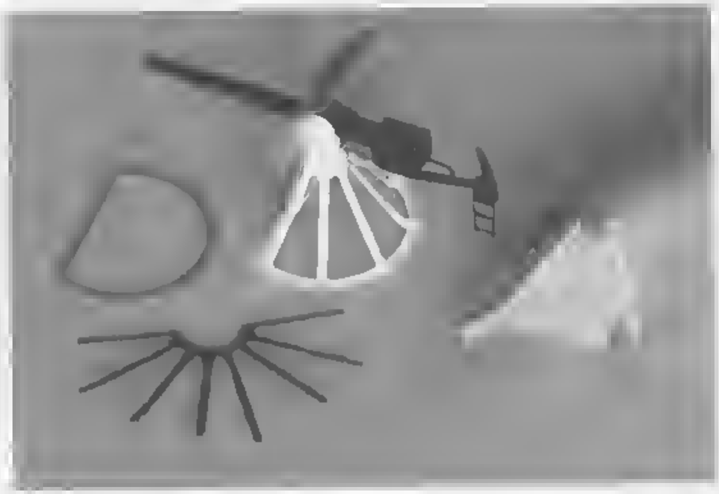


Fig.10.11 The etched parts for the gun mount shown together with the form tool for bending up the conical mount.

adjacent parts, the hull; or whatever!

Funnel cages

In the case of the two funnel cages shown in **Fig.10.9** all that is needed is to dome them. This can be done with the fingers freehand or, if a suitable curved object is available, bent around this. The ends must be bent horizontal to fit onto the top edge of the funnel top as in **Fig.10.10**. When drawing the component, length allowance must be made for the curvature otherwise the feet will not sit onto the funnel top correctly.

Gun mounts

Fig.10.11 shows the etched parts for a quick firing gun mount together with an assembled example. The figure also shows the turned fixture for shaping the spring mount before soldering it to the D-shaped base.

Annealing

It is debatable whether it is necessary to anneal before bending. The etched sheet in its "as received" state will be, to a certain extent, springy. This is a legacy of the rolling process to which it has been subjected when producing it as sheet material. Therefore to produce a given amount of curvature it will need to be over-bent and allowed to spring back to its natural equilibrium. If it needs to be annealed it must be raised to about 600°C. The way to do this without producing a distorted, oxidised component is to bend up a piece of tin plate, or similar sheet steel, into a tight fold like folding a piece of paper in half. Force open the edges and drop in the component to be annealed. Heat the whole assembly to about 600°C (you will have to guess this unless you have a pyrometer). Quench out by plunging into cold water, force open the sheet and out will drop a largely unoxidised, undistorted component, which will do your bidding i.e. bend and stay bent.

Ship's boats

It is unlikely that funnel cages will need

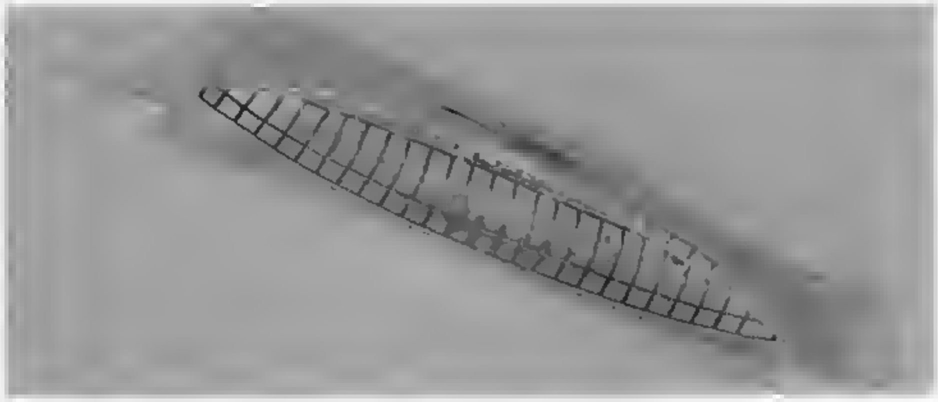


Fig.10.12 The etched ribs mounted into a transparent acetate hull.

annealing but timbers (ribs) for ship's boats most certainly will, to enable them to be dressed into the curves of the vessel's shell. **Fig.10.12** shows the annealed and formed ribs in place inside a transparent moulded acetate shell (hull).

Remember that annealed pieces are much weaker than when in their natural state.

Ship's wheels

This is an example where the accuracy of the computer's drawing ability and its repeatability (using rubber stamping) can be used to great effect. The parts drawn for the ship's wheels (there were five of them – obviously no steering engine) were:

1. The wheel body itself.
2. The hub.
3. The brass reinforcing ring.

See **Fig.10.13**.

The maximum thickness of the wheel measured approximately 0.03in. In this case sheets of 0.004in and 0.008in had been prepared and each part had 14 parts etched in both thicknesses of sheet. The assembly was as follows. For each wheel two laminations of 0.008in were used as the central part including the handles with a lamination of 0.004in added to each side. These 0.004in laminations had their handles removed. The four etchings could be fixed together using cyano, epoxy, or solder. The wheel assembly was done using a drill to locate all the centre holes of the laminations and a pair of tweezers to clamp a spoke to rotate all the layers in line.

The accuracy of the etching allows accurate laminating of this type because all parts rubber-stamped are identical. With the four-lamination assembly cleaned up it can be painted prior to gluing the bare brass reinforcing and hub rings either side. These can be of 0.004in or 0.008in to suit. With 0.004in reinforcing pieces the total thickness becomes 0.032in which is near enough for the authors.

Fig.10.14 shows the assembled wheels fitted together with the laminated A frames.

Fig.10.13 Parts for ship's wheel: 1 – the basic wheel etching, 2 – the hub reinforcement, 3 – the rim reinforcement.

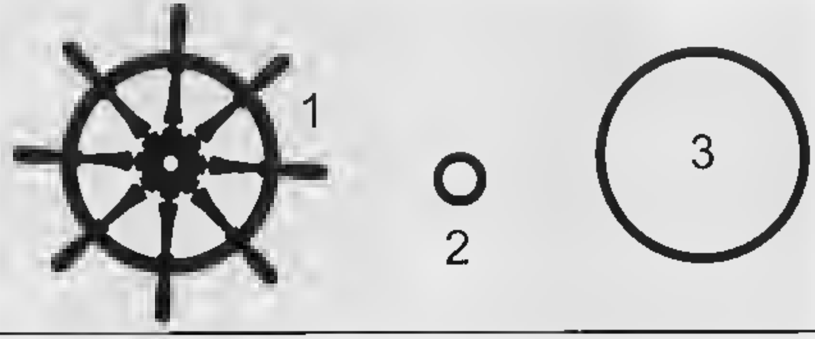


Fig.10.14 The steering position on RN "Duilio" showing the assembled steering wheels and the laminated A-frames supporting the steering shaft. Note also the steersman's gratings, skylight parts, guardrails, gun racers, deckhouse sides, companionway coaming – all etched parts.

Soft Soldering

I learned how to solder as an apprentice largely making up copper pipe work for test rigs. This, at least, gave me a feel for the process but it was a far cry from the sort of soldering required on the type of model that I build today. To start at the beginning, we must have: adequate heat, cleanliness to a very high degree, an efficient flux and suitable solder. These are the essentials and how we combine them is open to choice. I have tried several techniques and they all work if you get them right and that usually means after practice.

Heat - how you provide the heat is up to you with due regard to the job. A normal soldering iron can be used for applying solder to the work but a better job would be achieved if a thermostatically controlled iron of the type shown in **Fig.10.15** is used. I normally use a 25watt electric soldering iron, which is adequate for most work but I also use a 75watt iron for heat-hungry jobs. Trying to solder without an adequate heat supply is a doomed endeavour. A big iron

Fig.10.15 Home constructed thermostatically controlled soldering iron. See text.

is also useful if you want to get a lot of heat energy into a job in the shortest possible time to avoid unsoldering a nearby joint. On some jobs a flame is better as no physical contact with the work is necessary. I use a normal DIY butane type. Remember the hottest part of the flame is at the tip of the blue cone.

Cleanliness must be in the order of that required for plating. You need to establish an intermolecular bond between base metal and solder or, as we engineering types call it, the solder must "wet" or "tin" the surface. If it refuses to do so and "balls" up, forget it and re-clean the surface. This also applies to the tip of the iron. If a surface refuses to wet the cause may be lack of heat rather than dirt. Experience will quickly teach which is the cause.

Flux - there are two types of flux: passive and active. On copper and brass we normally use a passive type resin such as Fluxite. On steel we need an active flux such as "Baker's fluid" or zinc chloride (killed spirits). Both types need to be removed before painting especially the active ones as they can continue to be corrosive. I normally wash off using cold water and immerse in a weak solution of detergent to kill any further action. Even if you are using a passive flux a touch of Baker's fluid helps the solder flow enormously.

Solder - although some authorities suggest using soft solder alloys other than the standard electrical 60/40 resin filled tin/lead alloy, I have never found it necessary so to do. Tinman's solder, sold in sticks can be used but this is un-cored and will require external fluxing.

Solder paste or cream is also available and this is a liquid/paste of solder powder and flux. It can be applied with a brush or cotton bud before any heat is added, which enables the correct amount to be judged and prevents "blobbing". This advantage is offset by its expense and that the liquid tends to dry out and become more or less useless. Also if you do not apply heat for long enough to melt all the powder, you end

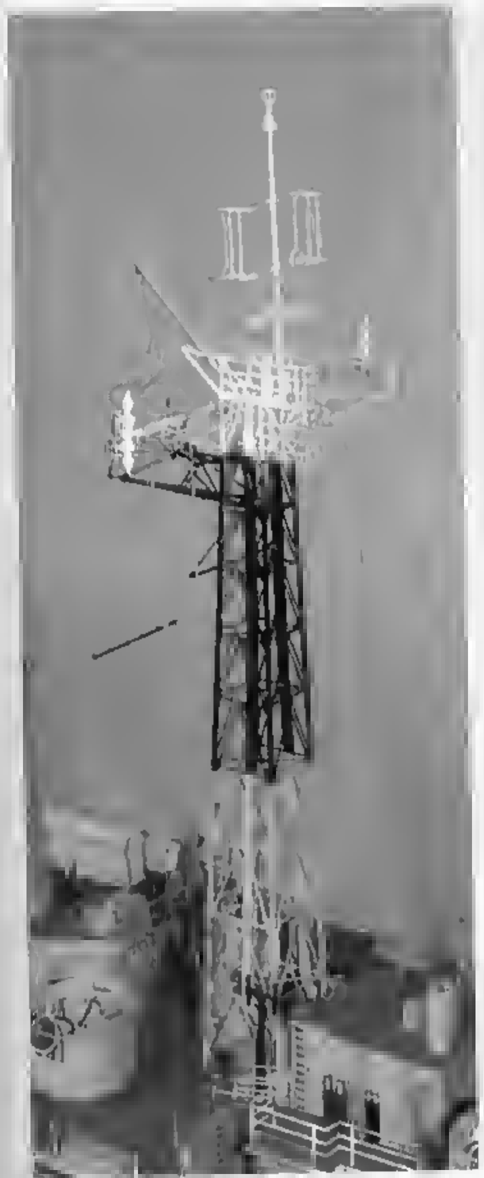


Fig.10.16 The mast on HMS "Belfast".

up with a mess needing to be cleaned off. However, paste does help the inexperienced in enabling limited amounts of solder to be applied. Excess solder can ruin a job and having to use mechanical methods to remove it i.e. chipping hammers, does tend to wreck delicate etching work! Even files can cause havoc.

Soldering technique

Having dealt with the basics I will now devote time to some cunning schemes to actually do the soldering. The received way to make a soldered joint is to tin both surfaces, bring them together and apply enough heat to melt the two surfaces together. Well that's the way I was taught. You can ignore the tinning bit and apply the solder to a ready-made **clean** joint and hope the solder tins and does the job in one stage as it were. Given the surfaces are clean and the flux in the solder and/or the extra flux applied does its job the joint should be satisfactory. The main problem here is you may get too much solder on the joint.

Excess solder, either at the tinning stage or on completion of the joint, can be removed using gravity to allow the solder to flow back onto the iron. Whilst tinning, a piece of wood closely following the iron will remove surplus molten solder. Copper braid is sold that will capillary up excess solder and solder pumps are also available but I find they are not really necessary.

If you use the gravity process it is usually followed by a wrist flick to rid the iron of the excess solder. For some totally unaccountable reason the distaff side do not like blobs of solder in their carpets so beware where you use this "wrist flick".

The three on two off phenomenon.

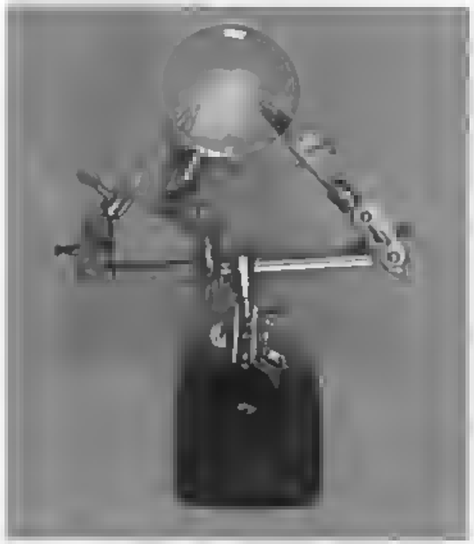


Fig.10.17 "Helping Hands".

Soldering jobs such as **Fig.10.16**, which is the mast of our beloved HMS "Belfast" now slumbering in the Pool of London requires, to say the least, planning. The sequence must be correct otherwise the three on, two off becomes a nightmare reality. Work out which joints will require the most heat i.e. those where most metal is concentrated and do those first. These can be followed by the "lesser" joints. Use heat sinks to absorb heat and to protect established joints. These can be metal clips or anything that will absorb heat and prevent it reaching and unsoldering already made joints. These will only have a limited life however. What I mean by that is if the whole job starts to become hot their protective powers will cease as they themselves will become hot. So quench out.

I have used a raw potato as a heat sink and this works well for really difficult jobs. If it all goes wrong you can always eat the chip!

Always remember that you can still glue in components if necessary.

One problem I have not mentioned is over-heating of the iron. The iron must normally run at a higher temperature than that of the melting point of the solder but this can lead to oxidation of the iron's tinning. In my book *Advanced Ship Modelling* (Special Interests Model Books) I describe a homemade temperature controller for a soldering iron that I use but space forbids a description here.

Three further points need to be made:

1. When etching or making parts that will have to fit together try to design in a mechanical fixing as well, as it makes soldering a doddle.
2. For parts fitted at an angle but still in one plane try pinning these down onto preferably a refractory block. These are available from Proops and the like. You can use wood but the scorching produces carbon residues, which can contaminate the joint.
3. For difficult compound angle joints "Helping Hands" is a boon. **Fig.10.17**

Incidentally for those difficult joints it pays to spend a great deal of time on setting up and getting everything properly tinned. A flame is probably best here rather than an iron, which may disturb the joint. Getting it right first time eliminates having to break it down, clean it and re-solder. This just wastes time and your patience!

Resistance Soldering Machines

Alternatively a resistance soldering machine of the type shown in **Fig.10.18** can be used especially for components with layers. This works like a spot-welding

Fig.10.18 *Resistance soldering machine.*

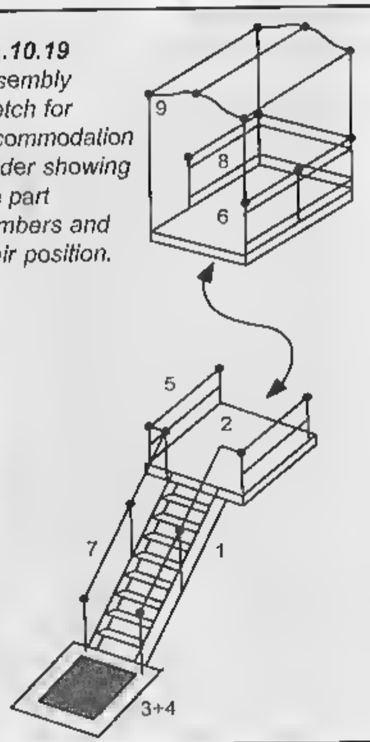


Fig.10.19 *Assembly sketch for accommodation ladder showing the part numbers and their position.*

machine producing low voltage/high current to melt solder paste, or whatever, placed between the laminations. In this way surface contamination is kept to a minimum.

Whilst this section has dealt with soldering at some length it is probably better to "design out" soldering if possible by clever design. Soldering of fine parts is not easy and can bring in a lot of unnecessary work. (The section on soldering is part of an article first published in *Model Boats magazine*).

Assembly of accommodation ladder

Before cutting out the pieces again check the drawings and the sketch (**Fig.10.19**) you made when designing the parts. This is to ensure that when cutting out the parts you do not cut off the odd part that looks as if it is just a connecting strip when in truth it is the piece that fills a gap on assembly. Keep a tight eye on these bits - put them into a container. You will find, once released

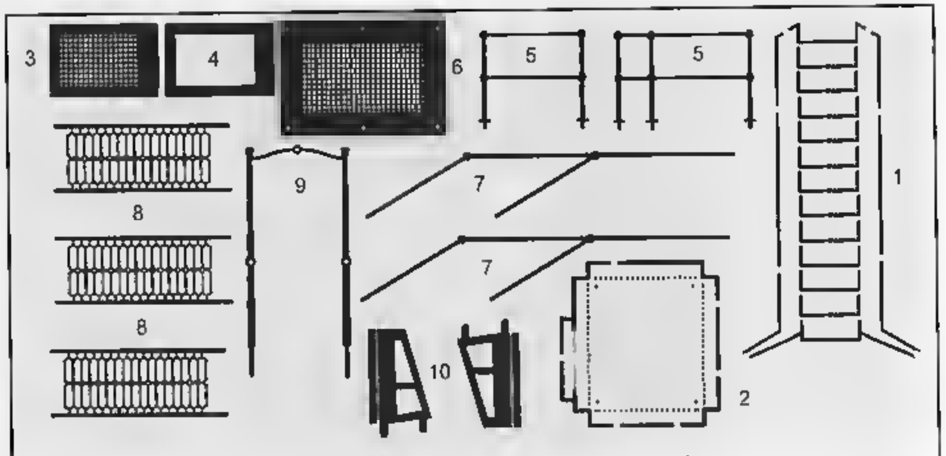


Fig.10.20 Drawings for the ladder parts with component numbers.

from the matrix, they have a life of their own and keeping all the parts together and off the floor is not easy. (**Fig.10.20** shows the etching drawings for the ladder parts).

Method of assembly

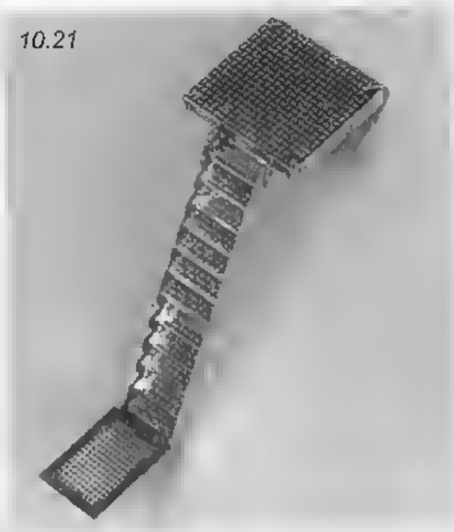
Start by folding up the two ladder stiles (1) and carefully bending the steps into place. Fold down the sides of the upper platform (2) and solder the ladder to it at the correct angle. Take the angle from the drawing (Fig.7.8) and set up an adjustable square to this angle as a check.

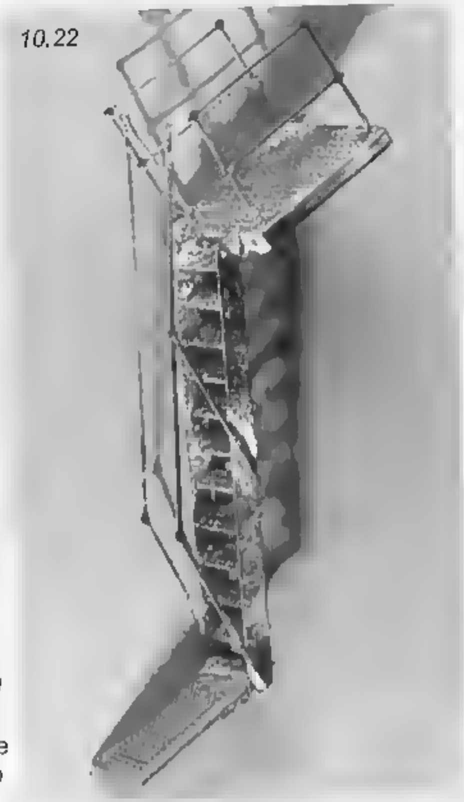
The lower platform is made up of two parts. The top is etched with a grating (3) and the underside is just a frame with no grating (4) and is only there to add thickness. These two pieces can be soldered together either with an iron or a resistance soldering machine. The wide margin end will need to be shouldered down a trifle on each edge, to allow it to be slid between the ladder stiles and under the lowest ladder step where it will rest on the ladder stile extensions. It can be soldered or glued in position. **Fig.10.21.**

The guardrails (5) around the top platform can then be fitted. The rear one has three stanchions and is "L" shaped. Two 3-stanchion etchings were drawn. One was cut down to make the front one which has only two stanchions. These are soldered in to the holes provided on the top plate (6). Because bending up is not very accurate the third hole for the rear stanchion must be drilled on assembly.

The last thing is to fit the guardrails (7) to the ladder. Although etched to the correct angle they are usually fiddly to get right. Fit the rear one first and get it correct before attempting the front one which should, of course, line up with the rear one perfectly. If it does not these railings will stand out like a sore thumb. Getting such obvious detail as an accommodation ladder perfect is an absolute must. (**Fig.10.22**)

The side deck platform to which the accommodation ladder is attached is a real piece of Victoriana with a traditional grid pattern screen (8) added to the guardrails.





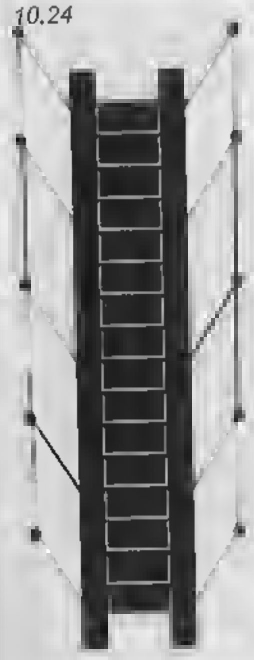
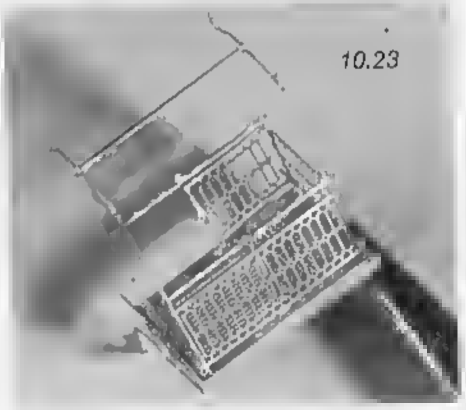


__Fig.10.21__ Accommodation ladder partly assembled. It important to get all the angles correct i.e. the slope of the ladder and the two platforms horizontal.
__Fig.10.22__ Fig.10.19 with handrails attached. __Fig.10.23__ The rather ornate deck platform which is the be attached to Fig.10.20.
__Fig.10.24__ Drawing of etched ladder with integral guardrails.



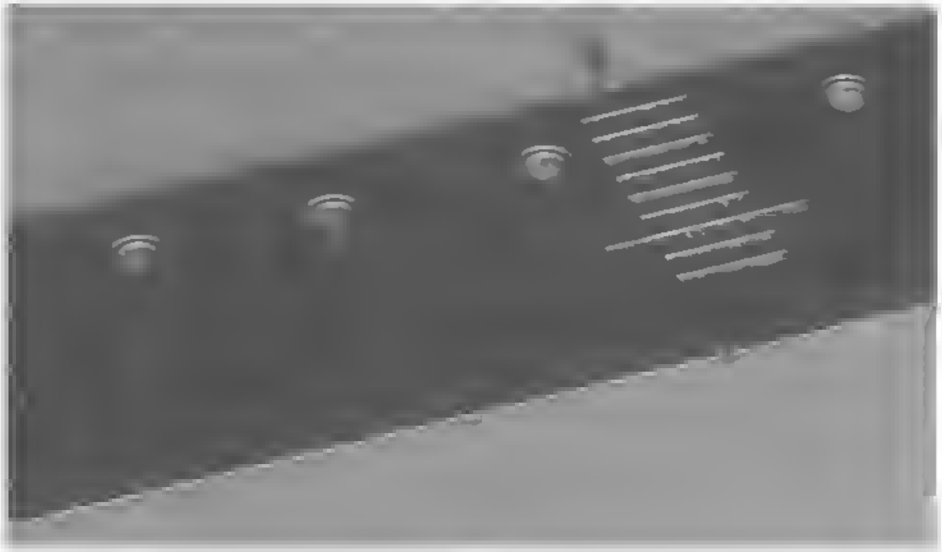


Fig.10.25 An example of an etched hull plate for a waterline model. Note the etched rigols and the series of rectangular slots to locate the hull steps. This latter ensures absolute accuracy in location. The vertical slot on the extreme left is a fixing for the searchlight position.

This screen was drawn as a repeated linear pattern after constructing just one element of the design – easy with a computer but a nightmare on a drawing board.

Three pieces of the screen were required and these were simply soldered to the supports for what we think was a canvas awning. (**Fig.10.23**). These two supports (9) were also etched. They were connected by three horizontal wires threaded and soldered in their etched holes with the odd spare stanchion supporting them (and the screens) in mid length. The design of the screen is shown in **Fig.10.18** (8). The whole unit was supported on two brackets (10) which connect to the hull side.

Sloping ladders of the type with steps always have handrails. With care the handrails can be drawn attached to the stiles so the whole ladder: steps, stiles and handrails becomes one etching. **Fig.10.24.** This does make folding-up more complicated but it may avoid some soldering. However, with some ladders the handrails are obviously, in real life, fitted as an addition and therefore, for realism, should be fitted as an addition. This usually results in the requirement for some nifty soldering. In these cases add heat sinks to ensure previously soldered pieces do not fall off. Clips of all sorts can be fitted just to provide more mass to avoid overheating. Also remember that with complicated assembly jobs all joints need not be soldered, some can be glued.

The assembly of the part is not the end

of the story. They need to be fitted to the hull, or whatever, and this should be done at the unpainted stage to avoid spoiling the finish at a later date. After fitting they should be removed, labelled and stored pending final assembly. This may sound unnecessary but complicated models have a very large number of components and it is vital to know where they go and to be able to find them when you want them.

As mentioned previously on certain ships we have used an etched plate as the surface of the hull. This has great advantages in accuracy, cleanness of detail and surface finish. **Fig.10.25.** Unfortunately it can only be adopted where there is curvature in only one plane. Unless you are a tin basher and have the tools, double curvature cannot be tolerated – well I can't anyway!

Another use of etching is as an appliqué. **Fig.10.26** shows a typical example of an etched door cyanoacrylated to a Perspex deckhouse.

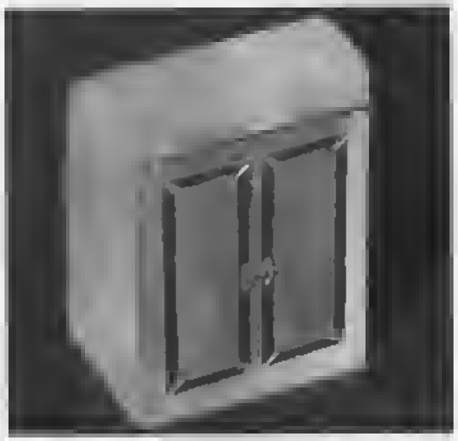


***Fig.10.26** An example of the use of half etched appliqué cyanoed to a Perspex block representing the heads. Note the long rigol over the doors.*

One last point is that having moved heaven and earth to produce accurate, fine detail do not obscure it with heavy painting. **Fig.10.27.** Always spray and do it lightly!

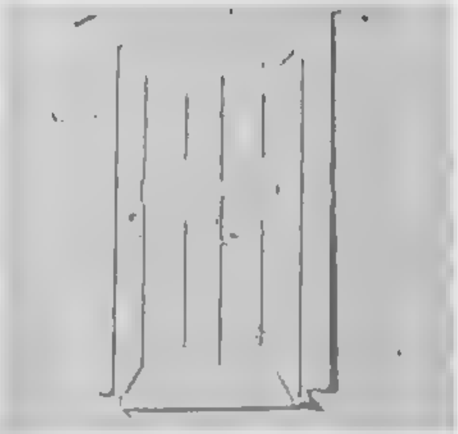


***Fig.10.27A Above Left**: a lightly sprayed etched door showing all the half etched detail. **B (Right)** – shows the effect of too much paint completely destroying most of the detail.*

ADDENDUM

If you are still with us it must be obvious by now that the process of metal photo etching is an answer to many problems on the way to producing complicated models. The barrier of producing "impossible" shapes has been removed. We still think that large areas of etching are best left to professional etchers with all their specialised equipment, knowledge and experience. However the etching is done the final quality depends largely on the artwork. The excellence or otherwise of this can be completely in your hands but patience, accuracy of drawing and design experience are required if the final product is to be satisfactory. It is in truth a different sort of modelling. To start with you have no physical bits in your hands, only ideas in your mind and you need to learn to think in a different way. Hard slog with a file has to be replaced with a complete understanding of the design of the component and the process of photo etching if success is to be achieved but it is all good fun if you don't weaken!

Brian King and Azien Watkin 2004